Natural Sciences and Engineering
Research Council of Canada

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Conseil de recherches en sciences
naturelles et en génie du Canada

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STRATEGIC GRANTS

SUBVENTIONS THÉMATIQUES

SUMMARIES OF COMPLETED RESEARCH PROJECTS

RÉSUMÉS DES TRAVAUX DE RECHERCHE TERMINÉS

May 1985

Mai 1985

Canada

AVANT-PROPOS

Le Conseil de recherches en sciences naturelles et en génie offre un programme de subventions thématiques visant à lancer ou à accélérer des projets de recherche dans des domaines d'intérêt national. Le but de ces subventions est de permettre aux chercheurs universitaires de contribuer davantage à la compréhension et à la solution de problèmes d'envergure nationale. Cette contribution peut prendre la forme de recherche appliquée pouvant avoir des retombées à assez court terme ou de recherche plus fondamentale destinée à accroître les connaissances dans des domaines d'importance éventuelle. En 1984-1985, le budget total du programme est de 32,25 millions de dollars.

Lors de sa création en juillet 1977, le programme de subventions thématiques ne comprenait que trois domaines choisis. Depuis lors, d'autres sont venus s'ajouter et il y en a maintenant huit: 1) l'alimentation et l'agriculture, 2) la biotechnologie, 3) l'énergie, 4) les matériaux et procédés industriels, 5) les océans, 6) le thème "ouvert" (regroupant des domaines d'intérêt national autres que les sept indiqués), 7) les télécommunications et l'informatique et, enfin, 8) la toxicologie de l'environnement.

Des comités de sélection composés de scientifiques et d'ingénieurs reconnus des secteurs universitaire, industriel et gouvernemental utilisent les critères suivants pour évaluer toutes les demandes:

- valeur scientifique de la recherche proposée;
- excellence des candidats;
- pertinence du projet par rapport au domaine désigné.

Chacun des critères a une importance égale. Pour être subventionné, le projet doit recevoir une cote élevée en fonction de chacun des trois critères. Les considérations régionales ne doivent pas entrer en ligne de compte pour l'évaluation des demandes. Les comités doivent déterminer la pertinence des divers projets et leur priorité à l'intérieur de chaque grand domaine désigné, en se basant sur les descriptions des domaines.

Le programme de subventions thématiques contribue à former des chercheurs et encourage le transfert technologique au secteur des utilisateurs: c'est ce qui explique son succès. Pour faciliter le transfert technologique, le CRSNG a compilé les résumés des projets de recherche en cours subventionnés dans le cadre de ce programme. Les personnes que ces projets intéressent sont priées de communiquer directement avec le chercheur concerné.

Le CRSNG offre d'autres programmes pour faciliter le transfert technologique. On peut obtenir de plus amples renseignements sur ces programmes en s'adressant au:

Conseil de recherches en sciences naturelles et en génie du Canada
200, rue Kent
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FOREWORD

The Natural Sciences and Engineering Research Council offers a program of strategic grants to initiate or accelerate research projects in areas of Canadian interest. The aim of the program is to enable university researchers to make greater contributions than in the past towards the understanding or solution of problems of national concern, either through specific applied research projects having potential for relatively short-term benefits, or through more basic research activities designed to develop knowledge in areas of potential importance. The total budget for the Strategic Grants Program for 1984-85 is $32.25 million.

When it was created in July 1977, the Strategic Grants Program only addressed three specific fields. Since then, new fields have been identified and added to the program and there are now eight: 1) biotechnology, 2) communications and computers, 3) energy, 4) environmental toxicology, 5) food/agriculture, 6) industrial materials and processes, 7) oceans, and 8) open (which includes areas of national concern other than the seven identified fields).

Selection panels composed of recognized scientists and engineers from the university, industry and government sectors rate all proposals using the following criteria:

- scientific merit of the proposed research;
- excellence of the applicants;
- relevance of the proposed research to the field.

Each criterion carries equal weight. To be funded, an application must receive a high ranking under each of the three criteria. Regional considerations do not enter into the evaluation of proposals submitted to this program. The panels are responsible for deciding what is relevant to, and of priority within, the broad areas identified for support consistent with the descriptions of the fields.

The Strategic Grants Program contributes to research manpower training and encourages the transfer of technology to the user sector. This is the basis of its success. To facilitate this technology transfer NSERC has compiled booklets of summaries of current research projects funded through the strategic grants program. Anyone interested in obtaining further information about these projects is invited to communicate directly with the researcher in question.

NSERC offers other programs to facilitate technology transfer. Further information on any of NSERC's programs may be obtained upon request by writing to:

Natural Sciences and Engineering Research Council of Canada
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STRATEGIC FIELD: BIOTECHNOLOGY

DOMAINE THÉMATIQUE: BIOTECHNOLOGIE

Natural Sciences and Engineering Research Council of Canada
Conseil de recherches en sciences naturelles et en génie du Canada

BIOTECHNOLOGY

Biotechnology is based upon the unique characteristics of biological materials such as microbial, plant or animal cells and enzymes; for the purposes of this program, biotechnology is considered to be the use of these materials to provide goods and services.

Strategic grants in this field present opportunities that will promote university research leading to the generation of new and improved techniques, process applications, products and the fundamental science that underlies them. Proposals should be of high scientific and technical merit and show a clear indication of socio-economic benefits, including personnel training.

Three principal areas of special needs and opportunities for research are described below; these are not meant to be exhaustive.

Techniques

This area includes the techniques and basic science underlying the exploitation of biological and biochemical processes, such as genetic engineering, the utilization of enzyme systems, fused-cell techniques, cell and tissue culture, and fermentation.

Process engineering, systems design and instrument development play a central role in the initiation, application and commercialization of biotechnology.

Process Applications

This area of research includes the innovative biotechnological aspects of nitrogen fixation, biomass utilization, waste treatment and utilization, mineral recovery, pharmaceuticals and chemical production.

Projects directly related to human health care (i.e. studies and tests in a medical environment) fall outside the terms of reference of this Council, but the development of animal and human health care products by means of the science disciplines supported by this Council can be considered.

LA BIOTECHNOLOGIE

La biotechnologie est axée sur les caractéristiques uniques de la biologie de la cellule et de ses constituents, comme par exemple, les cellules microbiennes, végétales et animales, ainsi que les enzymes; dans le cadre de ce programme on entend par biotechnologie l'utilisation de ces substances en vue de produire des biens et services.

Dans ce domaine, les subventions thématiques visent à promouvoir la recherche sur la mise au point de techniques, procédés, produits nouveaux ou améliorés ainsi que la recherche fondamentale sous-jacente. Il est important de noter que les demandes de subventions devraient faire preuve d'une grande valeur scientifique et technique et indiquer clairement les retombées socio-économiques prévues, y compris la formation de chercheurs.

Certains secteurs en biotechnologie ont été identifiés où il est nécessaire et opportun de faire de la recherche. Aux fins du programme ce domaine a été subdivisé en trois sections principales; cette description n'est cependant pas exhaustive.

Techniques

Cette section comprend les techniques et la recherche fondamentale nécessaires à l'exploitation des procédés biologiques et biochimiques, tels le génie génétique, l'utilisation des systèmes enzymatiques, les techniques de fusion cellulaire, la culture de cellules et de tissus, et la fermentation.

Il s'agit aussi de l'ingénierie des procédés, de la modélisation des systèmes et de la conception d'appareils, qui jouent un rôle clé dans l'établissement, l'application et la commercialisation de la biotechnologie.

Procédés

Cette section comprend entre autres les aspects biotechniques innovatifs de la fixation de l'azote, l'utilisation de la biomasse, le traitement et l'utilisation des déchets, la lixiviation des minéraux, les processus de fabrication des produits pharmaceutiques et chimiques.

D'après son mandat, le CRSNG ne peut pas subventionner des projets reliés directement aux soins médicaux (c.-à-d. études et essais dans un environnement médical), mais il peut subventionner la mise au point de produits servant à ces soins et aux soins des animaux, dans le cadre des disciplines scientifiques qui relèvent de sa compétence.

Products

In some instances, biotechnology may offer economically-attractive alternate routes to the manufacture of useful products. It is expected that this program will promote the application of biotechnology to the development of such new products as plant strains, pest control agents, pharmaceuticals, single-cell proteins, fuels and industrial chemicals.

February 1985

Produits

Dans certains cas, la biotechnologie pourrait offrir d'autres moyens plus rentables de fabriquer des produits utiles. On espère donc que ce volet favorisera les applications de la biotechnologie à la mise au point de nouveaux produits tels les nouvelles lignées végétales, biopesticides, produits pharmaceutiques, protéines d'organismes unicellulaires et produits chimiques industriels.

février 1985

BIOTECHNOLOGY/BIOTECHNOLOGIE

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- [ ] Industrial Materials and Processes / Materiaux et procedes industriels
- [ ] Oceans / Ocean
- [ ] Open / Ouvert

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SUMMARY

This investigation was concerned with finding a selective fungal pretreatment process which facilitated the separation of the chemical components of agricultural plant residues (straw) and poplar wood. Such a pretreatment allows the easy conversion of straw and wood to sugars for fermentation, aromatics for chemicals and the residual solids a potential soil conditioner or animal feed. Fungal pretreatment does not include the use of corrosive chemicals and their resulting waste stream treatment. Seventeen strains of wood decaying fungi where screened for their ability to slightly decompose lignin and not to degrade the polysaccharide components of straw. Three species of fungi were found to be effective and the work concentrated on them. The process uses the concept of solid state fermentation (SSF) which allows fungi to grow on aerated quiescent damp straw and wood in 4-17 L vessels. Best operating conditions were found for these fungi and effective pretreatment would take two to three weeks of SSF. Pretreatment caused the enzymatic release of sugars from polysaccharides to increase from 30 to 60 % (straw) and 10 to 20 % (wood). A SSF system uses simple technology which can be used on a large scale and easily applicable to rural communities here and in other countries.

PUBLICATIONS

Levonen-Munoz, E., Bone, D.H., Daugulis, A.J. Solid state fermentation and fractionation of oat straw by Basidiomycetes. Eur. J. Appl. Microbiol. Biotechnol. 18 120-23 (83).

Levonen-Munoz, E., Bone, D.H., Daugulis, A.J. Studies on fractionation of lignocellosics of oat straw by Basidiomycetes. Technical Report 25p Dept. Chem. Eng. Queen's University (1983).

Bone, D.H., Levonen-Munoz, E., Solid state fermentation of oat straw by Polyporus sp A-336 and the effect of added sugars. Biotechnol. Letters 6 657-62 (84).

Levonen-Munoz, E., Bone, D.H. Effect of different gas environments on bench-scale solid state fermentation of oat straw by white rot fungi. Biotechnol. Bioeng. February Issue (1985).

Formule 145 (1984)

FIELD OF RESEARCH / DOMAINE DE RECHERCHE
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- [x] Biotechnology / Biotechnologie
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Since much of the current and future impact of biotechnology is dependent upon the impressive catalytic abilities of the cell and its constituent enzymes, much current effort is focussed on producing superior biological catalysts. The best such catalyst is, however, of little value until an economical, industrial scale process has been built around it and its product. Industry traditionally utilizes the batch cultivation of free cells in stirred tanks with little concern for the compatibility of the bioreactor with a particular biocatalyst/product combination. However the economic advantages of continuous processes which utilize cheap, long-lived, free or immobilized cell catalysts in custom designed bioreactors has attracted growing attention. Since the few industrially viable processes of this kind involve simple, 1-2 step, enzyme or bacteria mediated conversions, the full potential of this new technology is yet to be realized. The goal of our interdisciplinary team of microbiologists, biochemists and engineers was to design and characterize bioreactors containing whole cell catalysts capable of converting simple nutrients into complex, high value pharmaceuticals. The long-lived (i.e. weeks - months), continuous production of 2 antibiotics - patulin and penicillin, and 2 monoclonal antibodies - anti-human transferin and anti-B blood group, by microbial (i.e. Penicillium) and animal (i.e. hybridoma) cells were chosen as model processes.

We have established the feasibility and industrial potential of long term semi-continuous and continuous antibiotic production using bioreactors containing immobilized microbial cell catalysts. This was accomplished by first developing a cheap new procedure for preparing large numbers of uniform, physically tough, polysaccharide gel beads of various diameters and densities. A novel sequence of spore entrapment, growth, and starvation yield beads densely colonized with cells which possess an antibiotic producing capacity equal to the best of free cell cultures. This protocol was equally successful with other filamentous microbes and gel types. The potential for scaling-up catalyst production was established with a custom designed attachment for the aseptic, continuous, casting of ∿0.5 million beads (2.5mm) in ∿2.5 h directly into a bioreactor. The colonization of inert diatomaceous earth or celite particles (1mm) was shown to be a successful alternative with excellent scale-up potential since bead casting is obviated. Next, the design of 1.2-16L stirred tank, 3-phase fluidized bed & airlift reactors along with 15-30 day production protocols demonstrated that production lifetimes for semi-continuous free cell processes could be significantly increased by 3-9 fold while a continuous process was only possible with immobilized cells because of catalyst "washout". Further enhancements in production longevity resulted from the development of media and feed protocols explicitly for the production phase. Extensive microscopic, diffusion and enzymatic characterizations provided a new understanding of reactor performance with respect to cell distribution, nutrient/product diffusion and the molecular basis of production longevity, and provide an excellent basis for the development of other processes.

In conjunction with a Canadian biotechnology company our work with animal cell bioreactors began with the successful entrapment of two hybridoma cell lines in a polysaccharide gel at high cell densities (2×10^6/mL). In a semi-continuous process these catalysts were shown to be 2.5 $\times$ more productive than were *in vitro* free cell cultures. However because of physical constraints on cell replication at the lowest possible gel strength, significant antibody production was restricted to ∿2 days. In contrast the development of a growth medium replenishment and purification process using "dialysis" reactors allowed free cell cultures to grow to exceptionally high cell densities with much better longevity and to exceed commercially viable antibody titers from *in vivo* free cell cultures. This and additional media development studies established the significant commercial potential of free hybridoma cell bioreactors.

BIBLIOGRAPHY: This project produced 20 lectures and conference presentations, 23 publications in scientific journals, two theses (Ph.D., M.Sc.), and a confidential contract research report to Chembiomed Ltd. A full publication list is included in our final report.

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FIELD OF RESEARCH / DOMAINE DE RECHERCHE
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☒ Biotechnology / Biotechnologie	☐ Communications and Computers / Telecommunications et informatique	☐ Energy / Energie	☐ Environmental Toxicology / Toxicologie de l'environnement
☐ Food-Agriculture / Alimentation et agriculture	☐ Industrial Materials and Processes / Materiaux et procedes industriels	☐ Oceans / Oceans	☐ Open / Ouvert

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Title of Project/Titre du projet: Studies and optimization of synthetic E. coli ribosome binding sites in industrial application for the expression and production of mammalian proteins in bacteria

Biotechnology, which has only begun a few years ago, has within this short period of time developed into one of the most exciting and active disciplines. One of its major aims is to super-produce important proteins using recombinant DNA technology. Many naturally occurring proteins or enzymes which are produced in different organisms in minute quantities are of great health, social and economic importance to man and his country. These are, however, of no commercial value unless they can be produced in large enough quantities economically. A promising approach involves the isolation or the syntheses of the genes that code for these proteins and their introduction into bacteria through cloning into plasmid vectors. These genes, however, will not be expressed into the specific proteins inside the bacteria because they lack the essential signals which are required for recognition by the bacterial protein-synthesizing machinery. We have been engaged in critical studies of these recognition signals and proposed to chemically construct some of these signal sequences for attachment in front of the foreign genes whose protein we wish to produce. When they are now introduced into the bacteria, the bacteria will recognize it as its own to produce these proteins. We have successfully constructed a plasmid vector containing all the necessary transcriptional and translational signals and used it for the high level expression of several mammalian genes in E. coli. These vectors contain appropriate restriction cleavage sites so that the control signals may be easily replaced by variants for structure-function studies. It is hoped that by these studies, a better understanding of how these signals function may be achieved and an optimal plasmid vector can be constructed that would allow efficient expression of any cloned gene in bacteria. This is vital to the Canadian industry and economy. In the very near future, many laboratories and industry will be competing to super-produce many of these known or newly designed proteins and enzymes for marketing.

Publications resulting from this research project:

Publications in refereed journals:

Jay, E., Rommens, J., Pomeroy-Cloney, L., MacKnight, D., Lutze-Wallace, C., Wishart, P., Harrison, D., Liu, W. Y., Asundi, V., Dawood, M. & Jay, F. "HIGH LEVEL EXPRESSION OF A CHEMICALLY SYNTHESIZED GENE FOR HUMAN GAMMA INTERFERON USING A NOVEL PROKARYOTIC VECTOR", Proc. Natl. Acad. Sci:81, 2290-2204 (1984).

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Rommens, J., MacKnight, D., Pomeroy-Cloney, L. & Jay, E. "CHEMICAL SYNTHESIS AND MOLECULAR CLONING OF A BACTERIOPHAGE T5 (T5P25) EARLY PROMOTER", Nucleic Acids Res.:11, 5921-5920 (1983).

Jay, E., Rommens, J., Sood. A. & Jay, G. "GENE EXPRESSION: CHEMICAL SYNTHESIS OF E. coli RIBOSOME BINDING SITES AND THEIR USE IN DIRECTING THE EXPRESSION OF MAMMALIAN PROTEINS IN BACTERIA", Nucleic Acids Res:10, 6319-6329 (1982).

Publications in books:

Jay, E., Rommens, J. & Jay, G. "SYNTHESIS OF MAMMALIAN PROTEINS IN BACTERIA". CRC Reviews - Biotechnology: in press (1984).

Jay, E., Jay, F. & Jay, G. "COMPARISON OF SYNTHETIC RIBISOME BINDING SITES FOR THE EFFICIENT EXPRESSION OF EUKARYOTIC PROTEINS IN E. coli", Gene Amplification and Analysis, Papas, T. S., Rosenberg, M. & Chirikyian, J. (ed.), Elsevier Press. pp. 89-101 (1983).

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Title of Project/Titre du projet: Regulation of cellulase production in industrially important microorganisms.

The relation between growth and production of cellulolytic enzymes was studied in a number of different microorganisms, especially a Cellulomonas species. Cellulose was able to stimulate growth, even in an already rich medium. Adding glucose prevented cellulose breakdown and also prevented stimulation of growth by cellulose. During growth in the presence of cellulose, cells became attached to cellulose fibres. Such cells synthesized an external layer, probably of polysaccharide, which is thought to be involved in attachment to the fibres. Glucose prevented both attachment to the fibres and formation of this outer layer.

Although attachment of cells to cellulose fibres takes place during growth in its presence, such attachment does not seem necessary for cellulose degradation. This was shown by experiments in which cells were separated from cellulose fibres by filters or by layers of agar. In the latter situation the degradation of cellulose was increased, possibly by relief of catabolite repression of cellulase formation by glucose or other end products of cellulose degradation. Exploitation of this phenomenon might be used to increase cellulose breakdown.

Attempts were made to isolate catabolite repression resistant mutants, that is, those in which cellulose breakdown was no longer inhibited by glucose. Methods used included continued cultivation in presence of cellulose which, earlier results had suggested, might select for such mutants. Selection for resistance to glucose analogues and treatment with mutagenic agents was also attempted. None of these methods yielded repression-resistant mutants of Cellulomonas species.

A number of more cellulolytic strains were isolated from natural sources. It is suggested that additional screening of such sources is justified for obtaining more active cellulolytic microorganisms.

Publications arising from this work

M. Vladut-Talor, T. Kauri, and D.J. Kushner (1984). Nutritional control of growth and cellulose degradation by a Cellulomonas species. (Abstract) Canadian Society of Microbiologists meetings, Kingston, Ontario.

T. Kauri and D.J. Kushner (1985). Role of cell-to-fibre contact in bacterial degradation of cellulose. (Abstract) American Society for Microbiology meetings, Las Vegas.

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M. Vladut-Talor, T. Kauri, and D.J. Kushner (1985). Effects of cellulosic substrates on growth, enzyme production and ultrastructure of a Cellulomonas species (submitted to Can. J. Microbiol.).

FIELD OF RESEARCH / DOMAINE DE RECHERCHE
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- [ ] Food-Agriculture / Alimentation-Agriculture
- [ ] Industrial Materials and Processes / Materiaux et procedes industriels
- [ ] Oceans / Oceans
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Title of Project/Titre du projet: Studies on Detoxification of Pulp Mill Effluent. The Biological Degradation of Fish Toxic Substances as an Approach to Improvement of Water Quality.

The primary objective of this research is to develop commercially feasible methods for effective removal of toxic substances from Kraft and thermal mechanical pulp mill effluent. The present methods, employing aerated lagoons, in which the effluent materials are treated by sludges of microorganisms, are not reliable and their capacity for detoxification can vary depending on temperature, acidity or basicity of effluent, etc. As a result, toxic effluent can flow into lakes and rivers, where young fish are spawning, and cause fish kill. The present study has focussed on the identification of selected microorganisms (fungi or bacteria) that have the ability of converting these toxicants to fish non-toxic compounds. Such an organism (Mortierella isabellina) has now been isolated and studies to illustrate the detoxification of six of the toxic effluent constituents have been completed. Studies to expand the program to other toxic compounds, for example, the chlorinated phenolics, are underway. Also experiments to develop this methodology for the industrial biobasins are anticipated.

Publications

The biotransformation of dehydroabietic acid with resting cell suspensions and calcium alginate-immobilized cells of Mortierella isabellina. J. P. Kutney, L. S. L. Choi, G. M. Hewitt, P. J. Salisbury, and M. Singh, Appl. & Environmental Microbiology, accepted for publication 1985.

Studies related to biological detoxification of kraft pulp mill effluent. VII. The biotransformation of 12-chlorodehydroabietic acid with Mortierella isabellina. J. P. Kutney, G. M. Hewitt, P. J. Salisbury, M. Singh, J. A. Servizi, D. W. Martens and R. W. Gordon, Helv. Chim. Acta, 66, 2191-2197 (1983).

Studies related to biological detoxification of kraft pulp mill effluent. VI. The biodegradation of 12,14-dichlorodehydroabietic acid with Mortierella isabellina. J. P. Kutney, E. Dimitriadis, G. M. Hewitt, P. J. Salisbury, M. Singh, J. A Servizi, D. W. Martens and R. W. Gordon, Helv. Chim. Acta, 66, 921-928 (1983).

Studies related to biological detoxification of kraft pulp mill effluent. V. The synthesis of 12- and 14-chlorodehydroabietic acids and 12,14-dichlorodehydroabietic acid, fish-toxic diterpenes from kraft pulp mill effluent. J. P. Kutney and E. Dimitriadis, Helv. Chim. Acta, 65, 1351-1358 (1982).

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Title of Project/Titre du projet: Recombinant DNA technology and site specific mutagenesis

The studies completed during the tenure of this grant period used recombinant DNA technology to study the structure and function of regions of genes specifying initiation and processing of RNA transcripts, initiation of DNA replication and translational control. The approach was to study these processes in heterologous systems (i.e. across species barriers). Basic information about the structure and function of regulatory sequences has been obtained. These studies form the basis of continuing experiments which use site specific mutagenesis to make specific alterations in control regions in order to assess essential features of genetic regulatory regions. This basic information is also being used in the construction of the regulatable expression vehicles. Many aspects of recombinant DNA technology including gene cloning and transformation, restriction enzyme mapping, nucleotide sequence determination, vector construction, screening of recombinant libraries as well as other biochemical techniques have been used and have provided training for personnel in the techniques of modern molecular biology.

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McNeil, J.B., Friesen, J.D. (1981). Expression of the Herpes simplex virus thymidine kinase gene in Saccharomyces cerevisiae. Mol. Gen. Genet. 184, 386-393.

Storms, R.K., Holowachuk, E.W., Friesen, J.D. (1981). Genetic complementation of the Saccharomyces cerevisiae Leu2 gene by E. coli LeuB gene. Mol. Cell. Biol. 1, 8-36.

Kiss, G.B., Pearlman, R.E., Cornish, K.V., Friesen, J.D., Chan, V.L. (1982). The Herpes Simplex Virus thymidine kinase gene is not transcribed in Saccharomyces cerevisiae. J. Bacteriol. 149, 542-547.

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Christensen, T., Johnsen, M., Fiil, N.P., Friesen, J.D. (1983). RNA secondary structure and translation inhibition: analysis of mutants in the rplJ leader. EMBO. J. 3, 1609-1612.

Rose, A.B. (1984). M.Sc. Thesis, York University.

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FIELD OF RESEARCH / DOMAINE DE RECHERCHE
(Check one/cocher la case appropriee)

- [x] Biotechnology / Biotechnologie
- [ ] Communications and Computers / Telecommunications et informatique
- [ ] Energy / Energie
- [ ] Environmental Toxicology / Toxicologie de l'environnement
- [ ] Food-Agriculture / Alimentation-Agriculture
- [ ] Industrial Materials and Processes / Materiaux et procedes industriels
- [ ] Oceans / Oceans
- [ ] Open / Ouvert

Name/Nom: Linda J. REHA-KRANTZ
Department/Departement: Genetics
University/Universite: Alberta
Phone number (optional)/N° de telephone (facultatif): (403)432-5383
Title of Project/Titre du projet: Developing and testing mutator DNA polymerases as useful reagents for *in vitro* mutagenesis

Genetic analysis is a powerful research tool and because of advancements in genetic engineering it is now possible to do genetics in a test tube. Site-directed *in vitro* mutagenesis is a key component of what can be called "biochemical" genetics or "reverse" genetics. The ability to change systematically all nucleotides in a specific region of DNA allows the researcher to probe exhaustively that region of DNA. Such studies are necessary in elucidating the molecular basis of gene regulation, protein function, and even to engineer new enzyme activities and regulation patterns.

The goal of this proposed research is to develop mutator DNA polymerases as *in vitro* mutagenesis reagents along with the reaction conditions that will allow the researcher to produce any nucleotide change in a cloned DNA molecule. Several methods have been developed for site-specific *in vitro* mutagenesis. One *in vitro* mutagenesis technique utilizes nucleotide misincorporation in a preselected region of DNA. Normally, DNA is replicated accurately by DNA polymerases, but misincorporation can be increased by altering reaction conditions. Also, a mutator DNA polymerase would be predicted to be more efficient in introducing mutations. Mutator DNA polymerases which we are studying presently may prove to be good reagents for *in vitro* mutagenesis.

Formule 185 (1984)

FIELD OF RESEARCH / DOMAINE DE RECHERCHE
(Check one/cocher la case appropriee)

- [x] Biotechnology / Biotechnologie
- [ ] Communications and Computers / Telecommunications et informatique
- [ ] Energy / Energie
- [ ] Environmental Toxicology / Toxicologie de l'environnement
- [ ] Food-Agriculture / Alimentation-Agriculture
- [ ] Industrial Materials and Processes / Materiaux et procedes industriels
- [ ] Oceans / Oceans
- [ ] Open / Ouvert

Name/Nom: Michel Sylvestre
Department/Département: Centre de recherche en bactériologie, Institut Armand-Frappier
University/Université: Université du Québec
Phone number (optional)/N° de téléphone (facultatif): 514-687-5010
Title of Project/Titre du projet: Développement de souches bactériennes à haut degré de biodégradation des BPC, faisant appel aux techniques de fusions de protoplastes et de croisements sous pression de sélection.

Le problème des BPC est loin d'être résolu. Aucune technique actuelle physique, chimique ou biologique ne peut prétendre pouvoir détoxifier les BPC à un taux suffisamment rapide pour éliminer les quantités impressionnates ($2,3 \times 10^6$ kg) accumulés dans notre biosphère.

L'étude de moyens biologiques pour résoudre le problème des BPC pourra éventuellement servir de modèle pour des études semblables concernant d'autres polluants organiques halogénés. Notons par exemple que 70 parmi les 129 composés polluants jugés prioritaires par l'"Environnemental Protection Agency" américain sont des organo-halogènes.

De toute évidence, les deux ans de recherches subventionnés par l'octroi No G0947 étaient insuffisants pour nous permettre de développer des bactéries capables de dégrader efficacement tous les BPC. Cependant nos résultats nous ont conduits à des conclusions majeures et importantes.

1. La dégradation des BPC nécessite au moins deux ensembles de gènes dont l'un régit la conversion des BPC en chlorobenzoate et un second régit la dégradation des chlorobenzoates. Il n'existe pas de souches naturelles possédant à la fois ces deux ensembles de gènes.
2. La dégradation des monochlorobenzoates est spécifique de souche. Ainsi, nous avons isolé des souches capables de dégrader soit le 2-chlorobenzoate ou le 3-chlorobenzoate sans pouvoir dégrader les deux isomères. Il en va de même pour le 4-chlorobenzoate. Il s'en suit que pour développer une population capable de dégrader tous les isomères des BPC à faible teneur en chlore, il faudra avoir au sein de cette population toutes les souches dotées de la capacité de dégrader chacun des isomères du monochlorobenzoate.
3. En laboratoire, en exerçant une pression de sélection sur une population composée de souches possédant les gènes de dégradation des monochlorobenzoates avec des souches capables de transférer efficacement le 4-chlorobiphényle en 4-chlorobenzoate nous pouvons développer rapidement des populations capables de minéraliser complètement tous les monochlorobiphényles y compris le 2-chlorobiphényle, le 3-chlorobiphényle et plusieurs dichlorobiphényles dont un seul des deux noyaux benzénique est substitué par des atomes de chlore. Le développement de telles populations dans la nature n'a à ce jour jamais été mise en évidence.
4. Les populations développés par la technique de pression de sélection sont cependant instables et pour les stabiliser, il faudrait pouvoir rassembler dans un minimum de souches, tous les gènes nécessaires pour ces biodégradations. À ce chapitre, nous avons développé le matériel génétique requis pour ces croisements, incluant entre autre un "cosmide" construit à partir du plasmide PMW79. Par contre, notre étude nous amène à conclure que la recombinaison par fusion de protoplastes ne s'applique pas aussi facilement dans ce cas que dans le cas des transformations industrielles par les bactéries gram positives.
5. Par contre, les BPC substitués sur les deux noyaux benzéniques sont très récalcitrants et nous n'avons pas réussi en exerçant une pression de sélection sur les mêmes populations de développer des bactéries capables de les dégrader. Pour que cette technique puisse être applicable pour le développement de souches capables de dégrader les BPC à plus forte teneur en chlore nous suggérons d'ajouter aux populations de laboratoires des souches bactériennes capables de dégrader soit le 4,4'dichlorobiphényle (4CB), le 2,2' dichlorobiphényle ou le 3,3 dichlorobiphényle. Pendant notre étude, nous avons isolé et caractérisé huit souches bactériennes à partir de 200 environnements différents qui sont capables de dégrader le 4,4' CB.

Enfin, comme conclusion général, il faut admettre, et nos résultats nous en font prendre conscience que dans le domaine du développement de bactéries capables de dégrader les polluants organohalogénés, nous en sommes au tout début de la recherche, et deux ans de subventionnement, c'est bien peu par rapport à ce qu'il reste à réaliser.

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FIELD OF RESEARCH / DOMAINE DE RECHERCHE
(Check one/cocher la case appropriee)

- [x] Biotechnology / Biotechnologie
- [ ] Food-Agriculture / Alimentation-Agriculture
- [ ] Communications and Computers / Telecommunications et informatique
- [ ] Industrial Materials and Processes / Materiaux et procedes industriels
- [ ] Energy / Energie
- [ ] Oceans / Oceans
- [ ] Environmental Toxicology / Toxicologie de l'environnement
- [ ] Open / Ouvert

Name/Nom: Trevor A. Thorpe
Department/Département: Biology
University/Université: Calgary
Phone number (optional)/N° de telephone (facultatif): (403) 284-6126
Title of Project/Titre du projet: Forest improvement: Tissue culture propagation of conifers for reforestation.

Forests are Canada's most important natural resource and directly or indirectly employ some 10% of the working population. Since the forests are renewable, sustained forestry yield will be dependent on reforestation with superior plantlets. Micropropagation or the tissue culture production of planting stock is envisaged as playing direct and indirect roles in this process. In this project research was carried out in Calgary under the direction of Dr. T.A. Thorpe, and at Kelowna Nurseries B.C. under the direction of Dr. David I. Dunstan.

In general, the process of plantlet formation in conifers involves four distinct stages, namely (1) induction of shoot buds, (2) development and multiplication of these buds, (3) rooting of the shoots, and (4) hardening of the plantlets. The optimum requirements for each stage must be experimentally determined for each species. The experimental material consisted of surface-sterilized seed, aseptically germinated seedlings and surface sterilized vegetative buds collected in the field. Using the above approach protocols for producing plantlets in black spruce (Picea mariana), white spruce (P. glauca), lodgepole pine (Pinus contorta) and northern pitch pine (P. rigida), (as well as mulberry, Morus alba) was completed at Calgary during the project. The explants in all cases consisted of mature embryos or seedling parts such as epicotyls, on which buds were induced by the application of exogenous cytokinin in a defined medium. Preliminary studies were also carried out on protoplast culture, with cell suspensions and somatic embryogenesis in coulter, radiata and/or lodgepole pines. At Kelowna, shoots could be induced on entire bud explants, apices and bases of Douglas fir (Pseudotsuga menziesii), white spruce (Picea glauca) and sitka spruce (P. sitchensis). Base explants had a seasonal requirement for cytokinin, which along with the addition of NH_4NO_3 allowed for proliferation of dormant buds of Douglas fir of 12-17 year old trees. Optimizing other parameters has allowed for bud collections to be made over a 7-8 month period, instead of the original 1-2 month period.

PAPERS PUBLISHED

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2. Rumary, C. & T.A. Thorpe. 1984. Plantlet formation in Black and White Spruce. I. In vitro techniques. Canadian Journal of Forest Research. 14: 10-16.
3. Patel, K.R., N.S. Shekhawat, G.P. Berlyn & T.A. Thorpe. 1984. Isolation and culture of protoplasts from cotyledons of Pinus coulteri D. Don. Plants Cell, Tissue and Organ Culture. 3: 85-90.
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Forme 145 (1984)

STRATEGIC FIELD: COMMUNICATIONS AND COMPUTERS

DOMAINE THÉMATIQUE: TÉLÉCOMMUNICATIONS ET INFORMATIQUE

COMMUNICATIONS AND COMPUTERS

Canada's unique geographical and demographic situation, and its abundance of natural resources gives rise to special problems and opportunities in Communications and Computers. This field encompasses the conceptual, electrical and physical aspects of collecting, organizing, moving, storing, manipulating, presenting and using information.

Underlying needs for communications and computers research and development in Canada relate to:

a) development of the technologies and capabilities needed to be internationally competitive;

b) application of the new technologies and capabilities to resource based activities;

c) use of communications and computers to replace physical transport;

d) equalization of services between urban and rural areas.

The following are examples of areas of study. This list is by no means exhaustive.

1. Components, Devices and Materials

- Microelectronics
- High and low power devices
- High reliability components
- Optical and opto-electronic devices
- Millimetre and microwave components
- Sensors and transducers

2. Transmission

- Media characteristics
- Fixed and mobile equipment
- Satellite technology
- Spectrum utilization and allocation
- Error control

3. Networks

- Voice, video, data and computer networks
- Switching, multiplexing, flow control
- Protocols

TÉLÉCOMMUNICATIONS ET L'INFORMATIQUE

La situation géographique et démographique du Canada et l'abondance de ressources naturelles créent des occasions et des problèmes spéciaux en télécommunications et en informatique. Ce domaine englobe les aspects conceptuels, électriques et physiques de la cueillette, de l'organisation, de la transmission, du stockage, de la manipulation, de la présentation et de l'utilisation des informations.

Au Canada, on a surtout besoin de recherche et de développement portant sur:

a) le développement des technologies et des capacités nécessaire pour être compétitif sur la scène internationale;

b) l'application des nouvelles technologies et capacités aux activités basées sur les ressources;

c) l'utilisation des télécommunications et des ordinateurs pour remplacer les déplacements physiques;

d) l'égalisation des services offerts aux milieux urbains et ruraux.

Voici des exemples de sujets d'étude. Cette liste n'est pas complète.

1. Composants, dispositifs et matériaux

- La micro-électronique
- Les dispositifs de haute ou de faible puissance
- Les composants de grande fiabilité
- Les dispositifs optiques et opto-électroniques
- Les composants millimétriques et micro-ondes
- Les détecteurs et les transducteurs

2. Transmission

- Les caractéristiques des médias
- Les installations fixes et mobiles
- La technologie des satellites
- L'utilisation et l'attribution des fréquences du spectre électromagnétique
- Le contrôle des erreurs

3. Réseaux

- Les réseaux de transmission de la voix, des images et des données et les réseaux d'ordinateurs
- La commutation, le multiplexage, le contrôle de la circulation
- Les protocoles

4. Terminals and Communication Interfaces

- Input and output devices
- Software and hardware interfaces
- Storage, display and manipulation techniques
- Workstations
- Ergonometrics

5. Artificial Intelligence

- Expert systems
- Knowledge representation
- Robotics
- Computational vision
- Logic programming
- Natural language translation and speech understanding

6. General Techniques for Information Technology

- Software engineering
- Signal and image processing
- Pattern recognition
- Reliability analysis and testability
- Modulation and encoding
- Simulation and modelling
- Optimization and control

7. Systems

- Computer-based design systems (e.g. VLSI, CAD/CAM)
- Sensor-based systems
- Microelectronics-based systems
- Digital system architectures
- Distributed and parallel processing systems
- Fault tolerant systems
- Testing methodology
- Systems design methodology

Proposals with the following characteristics are encouraged:

a) cohesive group efforts and multidisciplinary approaches;
b) indications of strong links to users and industry;
c) potentially high-risk projects with clear long-term benefits.

It is important to note that applicants must clearly and realistically state objectives, milestones and deliverables, methodology, relevance, personnel training, and means of technology transfer to users and industry.

4. Terminaux et interfaces de télécommunication

- Les dispositifs d'entrée et de sortie des données
- Les interfaces de logiciel et de matériel
- Les techniques de stockage, d'affichage et de manipulation de l'information
- Les postes de travail
- L'ergonométrie

5. L'intelligence artificielle

- Les systèmes experts
- La représentation des connaissances
- Le robotique
- La vision par ordinateur
- La programmation logique
- La traduction des langues naturelles et la compréhension du discours

6. Les techniques générales en technologie de l'information

- L'ingénierie du logiciel
- Le traitement des signaux et des images
- La reconnaissance des formes
- L'analyse de fiabilité et la testabilité
- La modulation et l'encodage
- La simulation et la modélisation
- L'optimisation et le contrôle

7. Systèmes

- Les systèmes de conception par ordinateur (p. ex. VLSI, CAO/FAO)
- Les systèmes basés sur les détecteurs
- Les systèmes basés sur les dispositifs micro-électroniques
- Les architectures de systèmes numériques
- Les systèmes de traitement réparti et parallèle
- Les systèmes peu affectés par les erreurs
- La méthodologie d'essais
- La méthodologie de conception des systèmes

On encourage les chercheurs à soumettre des demandes mettant en évidence:

a) des efforts d'équipe cohérents et des méthodes multidisciplinaires;
b) des liens bien établis avec les utilisateurs et le secteur industriel;
c) des projets pouvant être risqués mais comportant des retombées à long terme.

On doit noter qu'il faut présenter d'une façon claire et réaliste les objectifs, les étapes et les résultats prévus, la méthodologie, la pertinence, la formation de chercheurs et la façon dont s'effectuera le transfert de technologie à l'industrie et au secteur des utilisateurs.

COMMUNICATIONS AND COMPUTERS/
TÉLÉCOMMUNICATIONS ET INFORMATIQUE

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Georganas, N. Electrical Eng. Ottawa	Packetized digital voice communication in a local computer network	32
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FIELD OF RESEARCH / DOMAINE DE RECHERCHE
(Check one/cocher la case appropriee)

- [ ] Biotechnology / Biotechnologie
- [ ] Food-Agriculture / Alimentation-Agriculture
- [x] Communications and Computers / Telecommunications et informatique
- [ ] Industrial Materials and Processes / Materiaux et procedes industriels
- [ ] Energy / Energie
- [ ] Oceans / Oceans
- [ ] Environmental Toxicology / Toxicologie de l'environnement
- [ ] Open / Ouvert

Name/Nom: **Dr. Kellogg S. Booth**
Department/Département: **Computer Graphics Laboratory**
University/Université: **University of Waterloo**
Waterloo, Ontario, Canada N2L 3G1
Phone number (optional)/N° de téléphone (facultatif): **(519) 888-4534**

Title of Project/Titre du projet: **2-D and 3-D Interactive Computer Graphics Modeling Systems**

The primary purpose of the research program was to begin exploration of 2-D and 3-D modeling techniques based on interactive computer graphics. The research plan involved the development and use of software written by the researchers for existing raster hardware and new calligraphic hardware requested under the strategic grant. Secondary goals in support of (or resulting from) the primary goal were the assessment of the relative merits of calligraphic vs. raster hardware, the creation of interactive documentation programs and commercial quality slide making systems, information provider systems, and exploration of interactive techniques and appropriate use of colour as a tool in analyzing data.

Significant new results were obtained relating to the Beta-spline representation of curves and surfaces. A formulation of Beta-splines was developed that extended the original theory to include two different techniques for varying the bias and tension shape parameters. A divided-difference formula was devised for Beta-splines that unifies them with the theory of B-splines, and a convex hull property was shown to hold for certain classes of the Beta-splines.

Rendering software was developed during the first year of the project for both classical B-splines and the newer Beta-splines. Prototype interactive tools using raster displays were written for describing curves and surfaces using B-splines, Beta-splines, and polygonal approximations to surfaces of revolution and extrusion. The rendering algorithms were extended to ray-tracing techniques using a variant of the Oslo algorithm for computing bounding boxes. A fairly complete modeling system for 2-D curves using B-splines and Beta-splines was implemented on a calligraphic display. The system serves as an experimental testbed for investigating the mathematical properties of both types of curves.

Microcode developed for the bit-slice microprocessor on the raster system, most of it using a C-subset compiler developed as part of the research program, has been a key tool in building software that achieves the functionality of calligraphic segmented display list processors using raster hardware. With this software capability, and related changes to the raster hardware to support the software, there is a clear preference for raster systems in almost all applications.

Information on the mathematics of splines is contained in the technical report:

An Introduction to the Use of Splines in Computer Graphics
B.A. Barsky, R.H. Bartels, and J.C. Beatty
Technical Report CS-83-09 (August, 1983)
Department of Computer Science, University of Waterloo
[currently out of stock, revised version in preparation]

Further information on all aspects of the research program may be obtained by writing directly to the principal investigator.

FIELD OF RESEARCH / DOMAINE DE RECHERCHE
(Check one/cocher la case appropriee)

- ☐ Biotechnology / Biotechnologie
- ☐ Food-Agriculture / Alimentation-Agriculture
- ☑ Communications and Computers / Telecommunications et informatique
- ☐ Industrial Materials and Processes / Materiaux et procedes industriels
- ☐ Energy / Energie
- ☐ Oceans / Oceans
- ☐ Environmental Toxicology / Toxicologie de l'environnement
- ☐ Open / Ouvert

Name/Nom: Michel DELFOUR (et Guy PAYRE, Génie Mécanique, U. de Sherbrooke)
Department/Département: Centre de recherches mathématiques
University/Université: Université de Montréal, C.P. 6128, Succ. A, Montréal, H3C 3J7
Phone number (optional)/N° de téléphone (facultatif): 343-7265 (see 343-7501)
Title of Project/Titre du projet: Diffuseurs thermiques de poids minimum pour les composants état solide de haute puissance des satellites de communication.

Les développements présents dans les satellites de télécommunication indiquent qu'ils seront plus gros, consommeront de plus en plus de puissance électrique et dissiperont des quantités de chaleur beaucoup plus grandes. Bien qu'il y ait de nombreuses façons de concevoir l'environnement thermique des charges utiles à l'intérieur du satellite, il est préférable d'aller vers celles qui donnent une bonne performance à bon marché, à poids faible et avec une grande fidélité. Les diffuseurs et radiateurs thermiques offrent ces avantages.

Un diffuseur thermique a pour but de maintenir des conditions thermiques adéquates pour la charge utile en évacuant la chaleur par les caloducs vers les radiateurs. Un radiateur thermique accepte un flux de chaleur fixe de la charge utile ou d'une autre source et l'évacue dans l'espace par le mécanisme de radiation. Cependant dans les deux cas, sans une conception soignée ces composants peuvent rapidement devenir encombrants et lourds. C'est précisément la conception de diffuseurs et radiateurs de poids minimum qui a été faite ici. Nous avons développé et mis en oeuvre de nouvelles méthodes d'optimal design basées sur des modèles d'éléments finis. Ces méthodes peuvent aussi être appliquées à d'autres problèmes d'optimal design de systèmes à paramètres répartis.

[1] M.C.DELFOUR, G. PAYRE, J.-P. ZOLESIO, "Design of a mass-optimized thermal diffuser", in Optimization of distributed parameter structures, Vol. II, E.J. Haug and J. Céa, eds, pp. 1250-1268, Sijthoff and Noordhoff, Alphen aan den Rijn, The Netherlands, 1981.
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[3] M.C. DELFOUR, G. PAYRE, J.-P. ZOLESIO, "Optimal design of a minimal weight thermal diffuser with constraint on the output thermal power flux", J. Applied Mathematics and Optimization 9 (1983), pp. 225-262.
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030

FIELD OF RESEARCH / DOMAINE DE RECHERCHE
(Check one/cocher la case appropriée)

☐ Biotechnology / Biotechnologie
☐ For 9-Agriculture / Alimentation-Agriculture
☒ Communications and Computers / Télécommunications et informatique
☐ Industrial Materials and Processes / Matériaux et procédés industriels
☐ Energy / Énergie
☐ Oceans / Océans
☐ Environmental Toxicology / Toxicologie de l'environnement
☐ Open / Ouvert

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Title of Project/Titre du projet: High-definition television

The objective of this project was to build a research facility and to carry out studies on the digital processing and coding of enhanced quality television signals for future services. The main application areas identified were improved quality NTSC composite television, component coded television and high-definition television.

We designed and built a system which allows us to: 1) digitally record, and store on disk, sequences of NTSC or high-resolution component colour video signals (according to the format specified in CCIR Recommendation 601), up to 80 seconds in length and occupying about one seventh of the active picture area; 2) display these sequences in real time on a high-resolution RGB monitor; 3) process the sequences on a VAX 11/780 computer and display the processed sequences in real time; 4) switch the display (glitch-free) between the original and the different processed sequences; 5) record, process and display full-frame still images in the same formats, with instantaneous switching between up to eight images. The system has been called the High-Resolution Digital Video Store (HDVS).

We studied techniques which can the enhance the picture quality attainable while maintaining compatibility with the current NTSC system. There are two main signal processing techniques required to achieve improved quality television within the NTSC standard. The first is three-dimensional spatiotemporal filtering to perform adequate separation of frequency multiplexed luminance and chrominance components. The second is sampling structure conversion, involving subsampling and interpolation, for improved display. A class of filters giving the best compromise between suppression of luminance-chrominance interference artifacts (cross-luminance and cross-chrominance) was determined on the basis of subjective viewing experiments. Techniques for down-conversion and up-conversion for NTSC transmission assuming the use of high-definition cameras and displays were also developed, and a system comprising motion-adaptive processing was proposed and optimized on the basis of viewing experiments.

An adaptive coding scheme based on the discrete cosine transform (DCT) and incorporating the properties of the human visual system was studied for the coding of high-quality images over a range of image resolutions. The interaction between the image resolution and the coding efficiency was studied, to determine the extra requirements for digital transmission of HDTV signals, as compared to standard TV signals.

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031

FIELD OF RESEARCH / DOMAINE DE RECHERCHE
(Check one/cocher la case appropriée)

- ☐ Biotechnology / Biotechnologie
- ☐ Feed-Agriculture / Alimentation-Agriculture
- ☒ Communications and Computers / Telecommunications et informatique
- ☐ Industrial Materials and Processes / Materiaux et procedes industriels
- ☐ Energy / Energie
- ☐ Oceans / Oceans
- ☐ Environmental Toxicology / Toxicologie de l'environnement
- ☐ Open / Ouvert

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Title of Project/Titre du projet: Packetized digital voice communication in a local computer network

The research on this project has resulted in the following contributions :

(a) Development of HYMAP, a new Multiple-Access Protocol for Bus Local Area Networks. This protocol is of the family of Carrier-Sensing Multiple-Access (CSMA) with Collision Detection (CD) and Deterministic Collision Resolution (DCR). CSMA-CD-DCR have very good performance for real-time applications, such as digital voice transmission, control of industrial processes, etc.

(b) Development of an 8086 microprocessor-based real-time simulator for the subjective evaluation of digitized voice over Local Area Networks. Any network environment can be handled by this simulator, provided that its transit delay probability distribution can be determined.

(c) Research and development of Integrated Data/voice stations (IDVS) over a single-channel, high speed, Local Area Network, such as ETHERNET. Two IDVS were designed and tested over an experimental 1.5 Mbit/s link. Integration of 16 Kbit/s voice and 9.6 Kbit/s data was successful.

Publications

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2. P. MUI and N.D. GEORGANAS, "Performance Evaluation of Two Multiple-Access Protocols", Computer-Communications, Vol.7, N°2, April 1984, pp. 73-78.
3. P. MUI and N.D. GEORGANAS, "Packet-Voice Performance Evaluation of Two Multiple-Access Protocols with the Use of an 8086-Based Real-Time Simulator", Proc. 1984 IEEE Intern. Communications Conf., Amsterdam, May 14-17, 1984.
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8. N.D. GEORGANAS et al., "Further Developments of the Local Area Network PLATON at the University of Ottawa", IEEE MELECON'83 Conference, Athens, Greece, May 1983.

032

☐ Biotechnology / Biotechnologie
☐ Food / Aliments
☒ Communications and Computers / Telecommunications et informatique
☐ Industrial Materials and Processes / Matériaux et procédés industriels
☐ Energy / Énergie
☐ Oceans / Océans
☐ Environmental Toxicology / Toxicologie de l'environnement
☐ Open / Ouvert

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Title of Project/Titre du projet: A Distributed Computer Based Message System

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Research of all kinds has always been stimulated by easily accessible, reliable, and inexpensive communications among researchers with similar interests. Face to face communication between Canadian researchers in geographically separated locations is very expensive while telephone communication is impeded by the time differences between the five time zones in which they live, and made almost impossible with colleagues in continents east and west of North America. Given the difficulties of reaching anyone by telephone with just one or two tries, the telephone does not provide a feasible or economic means of maintaining continuing communication. Electronic mail, on the other hand, has none of the difficulties of telephones, is generally faster, and allows for the communication of information that cannot be transmitted orally.

There are, however, at least five dimensions to the complexity of a modern electronic mail system suitable for use by researchers:

1. The system must assist the user in the composition, reading, filing and retrieving of messages;
2. The messages must include more than simple text; they should include programs, telidon images, voice encodings, computer chip designs, etc.;
3. The software must run on a number of different kinds of computers;
4. The system must be able to send messages over public telephone and data networks, but also over a variety of local area networks;
5. Because many different mail systems exists, the system must be able to interconnect with other systems.

Over the past four years a team at UBC has been testing the design of a message handling system EAN that deals with all five of these complexities. The software has been under test in Canada for the past year by CDNnet, a message and file transfer network for Canadian researchers, and in four countries in Europe. The tests indicate that through the expansion of CDNnet and its interconnection with other mail systems Canadian researchers can be provided with a facility second to that of no other country. A French version of EAN will also be available.

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FIELD OF RESEARCH / DOMAINE DE RECHERCHE
(Check one/cocher la case appropriée)

☐ Biotechnology / Biotechnologie
☐ Food-Agriculture / Alimentation-Agriculture
☒ Communications and Computers / Telecommunications et informatique
☐ Industrial Materials and Processes / Materiaux et procedes industriels
☐ Energy / Energie
☐ Oceans / Oceans
☐ Environmental Toxicology / Toxicologie de l'environnement
☐ Open / Ouvert

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Title of Project/Titre du projet: DYNAMICS AND CONTROL OF LARGE COMMUNICATIONS SATELLITES

Early entry into the space age through scientific satellites, Anik based domestic communications system and pioneering experiments in direct broadcasting using Hermes, Canada has remained at the forefront of the space communications technology. With our declared commitment (press release of 19 March, 1984 by Hon. Donald J. Johnstone) to remote sensing (ERS-1, RADARSAT), large communications satellite system to serve mobile users (MSAT), and collaboration with European Space Agency's L-SAT, Canada indeed aspires to maintain that state of excellence and provide leadership. Communications satellite is not merely a transponder as an electronic expert may think but represents a synthesis of several subsystems, each required to perform with exacting precision for total success of the mission. Attitude dynamics and control represents one such vital area. Recognizing the fact that the next generation of communications satellites are going to be more powerful, bigger and carry large flexible members, the following aspects are investigated:

I attitude dynamics of large communications satellites accounting for flexibility and environmental effects;
II transient attitude dynamics and control during deployment of larger flexible members of communications satellites;
III hybrid active/passive control to improve useful life of communications satellites and thus make them more cost effective;
IV prelaunch test of communications satellites (e.g. direct broadcast systems) using the Space Shuttle.

The study provides fundamental understanding concerning complex interactions between libration-dynamics, deployment and flexibility. A general character of the formulation makes it applicable to a large class of present and next generation of communications satellites. The procedure is also applicable to the Space Shuttle based construction of structural members. With the U.S. commitment to a near earth space platform by 1992 and the Canadian interest to participate in it, the study represents a stepping stone to achieve that goal.

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(Check one cocher la case appropriée)

☐ Biotechnology / Biotechnologie
☑ Communications and Computers / Télécommunications et informatique
☐ Energy / Énergie
☐ Environmental Technology / Technologie de l'environnement
☐ Food Culture / Aliments non Agriculture
☐ Industrial Materials and Processes / Matériaux et procédés industriels
☐ Oceans / Océans
☐ Other / Autre

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Title of Project/Titre du projet: Digital Filter Implementation for Digital Communication Systems

SUMMARIES

1)A Binary Quantized All-Digital Phase-Locked Loop [1]*

A new refinement on the existing solutions for the digital PLL has allowed for an even closer approximation of the performance characteristics with those of an analog PLL. It represents a definite improvement in performance over presently existing digital phase-locked loops.

2)An Efficient Multifrequency Receiver Design Using Aliasing Techniques [2]*

SUMMARY: An experimental digital multifrequency receiver was designed and implemented in order to verify the hypothesis that aliasing techniques can be used to improve the performance/cost ratio of these systems.

3)A TMS-320 Based Touch-Tone Receiver Using Linear Prediction [3]*

A spectral estimation technique using linear prediction is explored for a DTMF receiver. (The model has been implemented on the TMS 320 signal processor and its performance evaluated).

4)Adaptive Filter Realization with a Minimum Number of Multipliers [4]*

A realization of an adaptive FIR filter is presented here based on the delta modulation digital filter which requires only 3 multipliers for any filter length when the filter is fully implemented for maximum speed of operation. All the coefficients are updated at every iteration, which enables the algorithm to converge faster relative to other cost efficient adaptive filter implementations.

5)Application of ROM Stored Square Multipliers [5]*

SUMMARY: To eliminate binary multipliers from digital signal processing hardware, a variation on the Stored Product Digital Multiplier, is the Stored Square Digital Multiplier. This technique is especially desirable from a circuit integration viewpoint as it allows for large scale integration of all its components, including the stored square ROMs, which all have the

6)Acoustic Echo Cancellation and De-reverberation [8]*

SUMMARY: The degradations affecting hands-free loudspeaking telephony have been systematically investigated, and the corresponding technology solutions have been analyzed. Theoretical investigations concerning computational (cost) attractive adaptive signal processing structures have been initiated. The reverberation (barrel effect) is more amenable (in the short term) to acoustic design solutions rather than signal processing ones because reverberation is an acoustic field phenomenon.

7)High Speed Signal Processing, Using Stored-Product Techniques [6][7]*

SUMMARY: New methods of realizing high speed FFT processors for radar signal processing, with input sampling frequencies in excess of 100 MHz are presented.

* For references, see the report attached.

(Check one/Cochez la case appropriée)

☐ Biotechnology / Biotechnologie
☐ Food-Agriculture / Alimentation-Agriculture
☒ Communications and Computers / Telecommunications et informatique
☐ Industrial Materials and Processes / Matériaux et procédés industriels
☐ Energy / Énergie
☐ Oceans / Océans
☐ Environmental Toxicology / Toxicologie de l'environnement
☐ Open / Ouvert

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Title of Project/Titre du projet:

FUNDAMENTALS OF SECURITY AND PROTOCOLS FOR COMPUTER-COMMUNICATION NETWORKS

SUMMARY

This strategic grant had two main objectives: (i) achieving data security by using cryptographic techniques and (ii) modelling and analysis of communication protocols.

(i) Data Security

The rapid developments in telecommunications and computer technology have created new opportunities for data collection, processing, storage and transmission. However, the extensive and easy access to all this data has created significant security problems. The risks include disclosure of confidential information, theft of assets by electronic means, fraudulent transactions, and destruction or contamination of valuable data. To address these issues, we have developed a variety of cryptographic algorithms and data security schemes. Althouth the DES algorithm has been adopted as a standard in the U.S., it is quite complex and some of its design criteria have not been made public. We have thus examined the principles of single key encryption algorithms and have concluded that fast, simple, and secure cryptographic schemes can be constructed. Related to this work, has been the development of tests for cryptographic algorithms. Although passing the tests do not ensure that a cryptographic algorithm is secure, they may reveal weaknesses in the algorithm without having to break it. The development of public key cryptography created the notion of digital signatures. Work has been done on digital signatures and a number of schemes have been proposed. A scheme has also been proposed for access control in a hierarchical system. Since one of the current implementation problems with the RSA public key algorithm is its slowness, integrated circuit designs have been developed and submitted for fabrication. Progress has also been made in the development of multi-level secure distributed systems which are necessary in an environment where more than one level of security is implemented.

(ii) Communication Protocols

The development and testing of communication protocols represent a major effort in the implementation of data networks. Until recently there was a lack of suitable techniques for the modelling and analysis of these protocols. We examined a number of modelling techniques and adopted the Petri Net representation for study. In our work, we adopted a number of carefully selected extensions which enhance the modelling power and ease of representation using Petri Nets. These extensions enable the Petri Nets to model a wide class of features of real protocols. Based on our experience in modelling protocols, we feel that the Petri Net technique can be a useful design aid for protocol development and testing. Progress has also been made in developing an interactive graphics facility for Petri Net modelling.

To gain some implementation experience with protocols, a balanced token-passing ring network was constructed which operated at a 1 Mbit/sec data rate. We are applying Petri Net modelling to this network in an attempt to verify its protocols.

References

An extensive bibliography of publications arising from this strategic grant is available from the grantee (S. E. Tavares) on request.

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FIELD OF RESEARCH / DOMAINE DE RECHERCHE
(Check one/cocher la case appropriee)

☐ Biotechnology / Biotechnologie
☐ Food-Agriculture / Alimentation-Agriculture
☑ Communications and Computers / Telecommunications et informatique
☐ Industrial Materials and Processes / Materiaux et procedes industriels
☐ Energy / Energie
☐ Oceans / Oceans
☐ Environmental Toxicology / Toxicologie de l'environnement
☐ Open / Ouvert

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Title of Project/Titre du projet: Message Management Systems

The management of office data involves the management of operational data, of communication data, and of procedure data. The goal of this research project was to develop an advanced-capability message management system capable of managing these three types of data in the office. A comprehensive summary of our research can be found in [6].

The management of operational data involves the ability to edit, format, file, and retrieve messages. A system that provides these capabilities was implemented [3]. The system allows a user to interactively design message templates for displaying messages on a high resolution bit-map display. The message contents are stored in a relational data base which allows the use of the data base querying and filing capabilities for retrieving and storing messages. The capabilities of the data base system were enhanced by designing and implementing an efficient storage and access mechanism for handling variable length text data [1, 8].

The management of communication data involves the ability to send messages and to specify logical routings for messages [7]. We investigated the problem of message routing in existing communication environments (i.e., the UNIX mail system). A system for automatically routing UNIX mail messages was designed and implemented [2]. The system allows a user to specify the recipients of a mail message dynamically and to gather responses from recipients for eventual return to the sender. In addition, a language for specifying message routing in general office environments was designed and implemented [4].

The management of procedure data involves the ability to specify and store office procedures that make use of the operational and communication data. General properties of automated procedures in an office system were investigated and a programming environment for implementing office procedures was designed and implemented [5].

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FIELD OF RESEARCH / DOMAINE DE RECHERCHE
(Check one/cocher la case appropriee)

- ☐ Biotechnology / Biotechnologie
- ☐ Food-Agriculture / Alimentation-Agriculture
- ☒ Communications and Computers / Telecommunications et informatique
- ☐ Industrial Materials and Process / Materiaux et procedes industriels
- ☐ Energy / Energie
- ☐ Oceans / Oceans
- ☐ Environmental Toxicology / Toxicologie de l'environnement
- ☐ Open / Ouvert

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Title of Project/Titre du projet: Multiple Access in Satellite Networks

Satellite communication is of special significance to Canada because of Canada's vast, often difficult terrain; rough cold weather; and scattered population centers. Satellite packet broadcast communications combine the advantages of packet-switching with those of satellite broadcast systems. Among these advantages are efficient load averaging, multidestination or conferencing capability, absence of topology and routing problems, and overall system simplicity.

The design of an efficient multiple access scheme is of prime importance in broadcast communication networks. Most of the present day satellite networks use the demand assigned FDMA/TDMA schemes (which are similar to centrally controlled circuit-switching) and are in the transition phase to opt for more efficient schemes (which use distributed control). The aim of this research was to develop better analytic models for the existing schemes and suggest efficient new schemes which will be utilized by industry and government.

In the area of dynamic control procedures of multiple access protocols we have shown that the Urn scheme performs better than optimal Aloha for all values of the expected throughput and that the performance of the Urn scheme approaches towards that of the optimal Aloha as the number of terminals approaches infinity. The dynamic behaviour of the Urn scheme has been discussed and compared with that of the Aloha schemes. It has been also shown that the Urn scheme exhibits bistability in a manner similar to the Aloha schemes however, in the former the effect of saturation is absent. Some existing approaches to performance optimization using input control procedures have been also discussed.

In the area of channel control via buffer monitoring we have shown that for the slotted system, if the system state is known to each terminal at the beginning of every slot, then an efficient control policy is to let each terminal in the k-th group attempt transmission with a predetermined probability and the terminals of all the other groups with probability zero. (We name this scheme Buffer Monitored Aloha or BMA). We have also discussed a special feature of attraction of a simpler scheme, in the context of partial information of the the system state. We were also found the steady-state expected delay versus expected throughput characteristic of BMA.

In the area of buffer design in multiple access protocols, we have described a queueing model to evaluate system performance for the case of a finite but arbitrary buffer size of length K. The model is general and can be applied to any controlled or uncontrolled Markovian scheme that is stationary from slot to slot. As special cases we tested the model for the optimal Aloha and Urn scheme.

The results show that increasing buffer lengths reduce the probability of packet rejction and increase the expected delay. The expected delay versus expected throughput characteristic of a system with a large buffer length is similar to the one having a smaller buffer length but more terminals.

038

STRATEGIC FIELD: ENERGY

DOMAINE THÉMATIQUE: ÉNERGIE

ENERGY

In the field of Energy, strategic grants promote high-quality, mission-oriented energy research and development in Canadian universities.

The OBJECTIVE of the program is to help bridge the gap between basic research programs in universities and applied energy research and development programs in government and industry.

The BENEFITS of the program will be novel and more accessible energy information, an enhanced technical manpower base, and accelerated development of high technology in the energy field. New products, processes and improved energy efficiencies developed through this program should give Canadians a competitive edge in world markets.

PRIORITY will be given to university groups which seize opportunities and address needs relevant to the changing Canadian energy scene.

Both fundamental and applied research proposals are eligible; however, relevance to the field of energy must be clearly established in the submission. The following list of fields, which is not meant to be exclusive, indicates areas in which strategic grant proposals will be considered.

1. Energy Sources and Fuel Conversion

   - Hydrocarbons and carbonaceous fuels (recovery, refining, liquefaction, gasification, etc.)
   - Nuclear fuels
   - Hydrogen as a fuel
   - Wood and biomass
   - Photochemical processes

2. Energy and Power Production Systems

   - Combustion and fuel cells
   - Heat engines and heat pumps
   - Fission and fusion technologies
   - Solar systems (thermal and photoelectric)
   - Other renewable (wind, hydraulic, tidal, geothermal)
   - Other renewables

3. Energy Transmission and Storage

   - Electricity transmission
   - Pipeline and other fuel transport technologies
   - Physical, chemical, and mechanical storage (batteries, pump storage, etc.)
   - Storage of hydrogen and hydrocarbons (tanks for CNG, H_2, etc.)

4. Energy Conservation and End-Use

   - Efficient home building, heating, and lighting
   - Heat recovery systems
   - Energy efficient machinery and processes (motors, control systems, etc.)
   - Transportation systems

L'ÉNERGIE

Dans le domaine de l'énergie, les subventions thématiques favorisent au sein des universités canadiennes des projets de recherche et développement orientés de haute qualité.

L'OBJECTIF est d'aider à combler l'écart entre les programmes de recherche fondamentale des universités et les programmes de recherche et de développement appliqués du gouvernement et de l'industrie.

Les AVANTAGES: des informations originales et plus accessibles, une main-d'oeuvre spécialisée plus compétente et un développement accéléré de la haute technologie en matière d'énergie. Les produits et les procédés nouveaux et les moyens plus efficaces d'utilisation de l'énergie mis au point grâce à ce programme devraient permettre aux Canadiens d'être plus compétitifs sur les marchés mondiaux.

On accordera la PRIORITÉ aux groupes de chercheurs universitaires qui s'attaquent à des problèmes pertinents et répondent aux besoins de la situation énergétique canadienne en évolution constante.

Les projets de recherche fondamentale et de recherche appliquée sont admissibles, mais leur pertinence par rapport au domaine de l'énergie doit être clairement établie dans la demande. Voici une liste (non exhaustive) de domaines qui peuvent faire l'objet de demandes de subventions thématiques.

1. Sources d'énergie et conversion du combustible

   - Hydrocarbures et combustibles carbonés (récupération, raffinage, liquéfaction, gazéification, etc.)
   - Combustibles nucléaires
   - Hydrogène (comme combustible)
   - Bois et biomasse
   - Procédés photochimiques

2. Procédés de production d'énergie et d'électricité

   - Combustion et piles à combustible
   - Machines thermiques et thermopompes
   - Technologies de la fission et de la fusion
   - Systèmes solaires (thermiques et photoélectriques)
   - Énergie renouvelable (éolienne, hydraulique, marémotrice, géothermique)
   - Autres genres d'énergie renouvelable

3. Transmission et stockage de l'énergie

   - Transmission de l'électricité
   - Pipelines et autres techniques de transport du combustible
   - Stockage physique, chimique et mécanique (batteries, pompes, etc.)
   - Stockage de l'hydrogène et des hydrocarbures (réservoirs de CNG, H_2, etc.)

4. Conservation et consommation de l'énergie

   - Construction domiciliaire, chauffage et éclairage efficaces
   - Méthodes de récupération de la chaleur
   - Procédés et machinerie efficaces (moteurs, systèmes de contrôle, etc.)
   - Systèmes de transport

Subsections common to all of the above categories are modelling and analysis, by-product and waste-product management, and environmental concerns.

Self-sufficiency and the net energy saved or produced are important factors in the selection process. Proposals addressing short-, medium-, or long-term objectives are welcome but all applications must present a time-frame for implementation of the proposed technology.

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la modélisation et l'analyse, la gestion des sous-produits et des déchets, ainsi que les considérations environnementales sont des subdivisions communes à toutes les catégories susmentionnées.

On doit noter que l'autosuffisance et la quantité nette d'énergie économisée ou produite sont des facteurs importants lors de la sélection. Les propositions décrivant des objectifs à court, moyen ou long terme sont admissibles, mais toutes les demandes doivent présenter un échancier de mise en oeuvre de la technologie proposée.

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- ☐ Industrial Materials and Processes / Materiaux et procedes industriels
- ☒ Energy / Energie
- ☐ Oceans / Oceans
- ☐ Environmental Toxicology / Toxicologie de l'environnement
- ☐ Open / Ouvert

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Title of Project/Titre du projet: Rotary Engine Developments

The Rojet is a radically new engine concept with features different from all other internal combustion engines. A rojet engine consists of a revolving platform on which 2 jets are mounted, with a tangential component of flow. The thrust from their exhausts drives the rotor and during the rotation air is forced through the intakes and mixed with fuel that is injected from the axis. The exhaust gases are captured in a chamber with stator blades vanes that change the direction of flow and generate a back-up pressure which increases the efficiency. The engine is started with a starter motor coupled by a clutch to the main axis and an auxiliary ignition system. Once the jets are ignited at sufficiently high revolution rate the thrust overcomes the friction in the bearings and the engine speeds up and adjusts itself to a stable revolution rate where the power input is matched to the load. The ignition can be switched off while the jets are running. No timing for the ignition is needed. The air fuel ratio is controlled by the rotor speed and the fuel input. The engine has no sliding seals.

We have build a Rotary jet engine which can accept liquid or gaseous fuels. The rotor has a radius of 200 mm. Fuel is administered through a pipe on the rotation axis. Ignition is achieved with a transformer with rotating secondary coil mounted on the rotor. A magnetic induction system has also been prepared. Three other ignition systems were also considered and discarded. Tests with gaseous fuels show that the engine must be revved up to more than 1700 RMP for starting.

The motor is controlled by a control-logic system which would shut off the fuel supply under three conditions: (1) If the rotor would speed up to a revolution rate outside some predetermined range; (2) if the temperature at critical control points would exceed certain limits or (3) if any fuel fumes would be detected at control points. This system worked quite satisfactorily for all tests. A fuel lid with needle valves that rotate in the rotor block was designed and built and is ready for testing. The needle valves are activated through a mechanical link that is mounted on the rotation axis. The link rests on a sealed ball bearing to allow frictionless rotation. The axial link is hollow and it has the fuel line on its axis. The first version of the jets featured daisy leave valves of the standard pulsed jet design which have a limited lifetime. Recently, we have developed a valveless pulsed jet which has successfully run on our stationary test stand. Further tests have to wait for a new source of funding.

FIELD OF RESEARCH / DOMAINE DE RECHERCHE
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☒ Energy / Energie
☐ Oceans / Oceans
☐ Environmental Toxicology / Toxicologie de l'environnement
☐ Open / Ouvert

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Title of Project/Titre du projet: Fundamental Studies and System Development for Combustion of Solid and Gaseous Fuels

Research was done on: (1) fluidized bed combustion (FBC), (2) pyrolysis and combustion of wood, and (3) diffusion flames of gaseous fuels in air. FBC is a new technology in which sulphur dioxide pollutant emissions are suppressed by limestone particles fed directly into the combustor. Fuels tested include Eastern Canadian coal, North African alpha grass, and Syncrude (tar sands) coke. The Queen's facility includes a pilot plant and several bench-scale systems. The work has involved fundamental research on the process and the development of a data base on the performance of Canadian coals and limestones. Research on wood pyrolysis and combustion has produced information for the design of wood-burning systems and wood-gasification systems. The research on flames has led to engineering correlations for predicting pollutant emissions (soot, unburnt hydrocarbons and nitrogen oxides) radiative heat flux, and flame size and shape. Four graduate students have completed thesis research and have found related employment. Three others are part-way through their work.

Publications

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FIELD OF RESEARCH / DOMAINE DE RECHERCHE
(Check one/cocher la case appropriée)

- ☐ Biotechnology / Biotechnologie
- ☐ Food-Agriculture / Alimentation-Agriculture
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- ☒ Energy / Energie
- ☐ Oceans / Oceans
- ☐ Environmental Toxicology / Toxicologie de l'environnement
- ☐ Open / Ouvert

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Title of Project/Titre du projet: "Caractérisation et chauffage des mélanges par l'énergie hyperfréquences".

Dans le chauffage de matériaux industriels (liquides, solides, gaz) par énergie micro-onde on doit souvent surmonter des difficultés liées au chauffage non-uniforme qui entraîne une baisse dans la qualité et la quantité de la production. La pratique démontre qu'une solution partielle serait de chauffer le produit avec certains temps d'arrêts du chauffage micro-onde permettant ainsi de laisser la température se stabiliser à un niveau plus uniforme avant d'appliquer de nouveau l'énergie micro-onde. Cette étude donne des méthodes de mesures sur des échantillons de matériaux industriels qui permettent de concevoir un traitement thermique dans des nouveaux fours bi-énergétiques produisant un cycle de chauffage plus rapide et plus uniforme. On peut utiliser avec les fours bi-énergétiques soit des courroies ou des enceintes à chargement périodique.

Les études diélectriques ont démontré que des mélanges diélectriques ayant une fréquence de relaxation en dessous de la fréquence de chauffage micro-onde sont plus aptes à produire des "avalanches thermiques" ou des "brûlures" dans le matériel car la fréquence de relaxation risque d'atteindre la fréquence de chauffage (soit 2450 MHz ou 915 MHz) lors de l'échauffement. En plus nous avons trouvé que des produits agro-alimentaires possèdent un hystéris de ϵ' et ϵ'' lors d'un cycle de chauffage. Nous estimons que la caractérisation des mélanges diélectriques est nécessaire pour bien composer les cycles de chauffage bi-énergétiques.

Chahine et al., "Computer Based Permittivity Measurements and Analysis of Microwave Power Absoption Instabilities", Journal of Microwave Power, Vol. 19, No. 2, 1984, pp. 127-134.

Akyel et al., "Measurement of the Complex Permittivity of Food Products during Microwave Power Heating Cycles", Journal of Microwave Power, Vol. 18, No. 4, 1983.

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FIELD OF RESEARCH / DOMAINE DE RECHERCHE
(Check one/cocher la case appropriée)

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☐ Food-Agriculture / Alimentation-Agriculture
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☐ Industrial Materials and Processes / Matériaux et procédés industriels
☒ Energy / Energie
☐ Oceans / Océans
☐ Environmental Toxicology / Toxicologie de l'environnement
☐ Open / Ouvert

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Title of Project/Titre du projet: Preparation, Structure and Electronic Properties of Semiconducting Films for Photovoltaic Applications.

SUMMARY

The objectives of this project included the production of quality polycrystalline semiconducting films (containing large crystallites) for device applications in general, and solar cells in particular. Many of the problems with polycrystalline thin films fabricated for device applications, are related to grain boundaries and other structural imperfections. To make progress in this area, one must be able to identify the microstructure in these films definitively. The development of this capability constituted an important part of this work. Transmission electron microscopy is a particularly powerful tool for this purpose, but the preparation of specimens from thick films can be a very difficult problem. Cross-sectional TEM (XTEM) specimens are prepared using a unique ion-milling apparatus constructed in our laboratory. It allows one to prepare XTEM specimens of films that etch more rapidly than the substrate, which is often the case. It also allows etching at very shallow angles (less than 10 degrees), yielding samples of uniform thickness. It is only recently that this technique has been available and for that reason, only a limited study of the effects of growth paramenters has been possible. The original idea was to use an electron beam to bombard the substrate as the film grows in order to influence the nucleation and growth and produce a better polycrystalline film. The development of an analytical method like XTEM was essential for this study. We have demonstrated that electron beam irradiation can produce a better polycrystalline film. A more complete systematic study of the main deposition parameters (e.g. beam energy, substrate temperature, beam current density, and deposition rate), is currently in progress to determine if polycrystalline films with the desired properties can be obtained. All of the necessary characterizing facilities are now operative. A state-of-the-art scanning laser microscope (spot size 1.6 microns) has been developed and a fully computerized prototype is in use. A company has been formed "Waterloo Scientific Inc.", to manufacture and market the instrument. It is useful for studying the electronic structure in very localized regions (e.g. at grain boundaries) in both films and complete devices. A new apparatus has been developed that uses microwave absorption to determine minority carrier lifetimes in a small region of the semiconductor (typically illuminating areas of 0.3 mm diameter). This is an important characterizing experiment for evaluating the quality of polycrystalline wafers and device grade films. Finally, an apparatus for studying Deep Level Transient Spectroscopy (fully computer interfaced) has been developed which allows one to observe both current and capacitance transients. In each case the complete transient is digitized and recorded for subsequent analysis. Deep trapping levels at the interface regions of a device or in the grains, may be detrimental to device performance. It is necessary to be able to study these and relate their presence to preparation conditions in order to optimize device performance. All of these techniques are essential for the systematic study required to improve the quality of vacuum deposited films, if they are to be used for device applications.

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Publications:

A.E. Dixon, S. Damaskinos, B.A. Oliver and R.T. Adsett, "Scanning Laser Microscope Measurements of Semiconductor and Device Properties", J. Can. Ceram. Soc., in press

A. Haque, A.E. Dixon and D.E. Brodie, "Effect of Electron Bombardment During Deposition of Cadmium Sulfide Films Using a Hot Wall Technique", Can. J. Phys., in press

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M. Trakalo, C.J. Moore, J.D. Leslie and D.E. Brodie, "Apparatus for Measuring Seebeck Coefficients of High-Resistance Semiconducting Films", Rev. Sci. Instrum. 55(5) May (1984)

R.D. Turner, C.J.L. Moore and D.E. Brodie, "Manual/Automated I-V System for Analyzing Solar Cells", Rev. Sci. Instrum. 55(11) Nov. 1984

Conference Presentations:

U. von Sacken and D.E. Brodie, "A TEM Study of Vacuum Deposited Polycrystalline Zn_3P_2", Phys. in Can. 40, 3 (1984)

S. Damaskinos and A. E. Dixon, "Measurement of Electronic Properties of Grain Boundaries", Phys. in Can. 40, 3 (1984)

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A. Haque, A.E. Dixon and D.E. Brodie, "Effect of Electron Bombardment During Deposition of CdS Films Deposited by a Hot Wall Technique", 2nd Can. S.C. Tech. Conf. (1984)

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R. Turner, C.J. Moore and D.E Brodie, "An Automated Solar Cell I-V Measurement and Analysis System", Thys. in Can. 39, 3 (1983)

Patent:

D.E. Brodie and J.H. Morgan, "Reactive Plating Method and Product" U.S. Patent No. 4415602, November 15, 1983.

FIELD OF RESEARCH / DOMAINE DE RECHERCHE
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☐ Oceans / Oceans
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Title of Project/Titre du projet: Spectroscopic studies battery electrodes and electrolytes

The chemical and physical properties of electrolytes of importance in lithium battery technology have been studied in solid, molten and solution phases by spectroscopic methods augmented by thermal analysis and X-ray diffraction methods. In favourable cases the spectroscopic techniques can provide a unique method to quantitatively identify discrete species in situ in working cells. The major goal of the work was the preparation and characterization of pure electrolytes and the identification and measurement of impurities that can lead to the undesireable side reactions that lead to cell failure.. Components of three cell types were investigated (i) LiAl/LiKCl eututic at 450°/FeS (ii) Li/SO_2 (iii) Li/$SOCl_2$.

Alkali metal sulfides and polysulfides are important reactants in all the above cells and attempts have been made to prepare pure compounds. Carbonate, hydroxide, polysulfides, thiosulfate and dithionate impurities are difficult to avoid but these can be monitored by infrared and Raman methods. Sulfur has been studied over wide range of temperature. Monoclinic sulfur was characterized in a meta-stable state down to 77K. Exchange studies with $^{34}S_8$, $^{32}S_8$ mixtures revealed that S_8 rings rapidly break and reform at 130°C.

A post mortem analysis of a LiAl/LiKCl eutectic battery has revealed Li and Al excursions in metallic form into the electrolyte and even into the cathode region. Aluminium short circuits are the most probable cause of cell failure. Many other species have been identified.

Raman studies of the LiKCl euectic melt provided spectroscopic support for a relatively stable tetrahedral Cl^- coordination about the Li^+ predict from transport measurements which indicated that the smaller Li^+ is less mobile than the larger K^+ (Chelma effect).

Raman studies of liquid SO_2 and $SOCl_2$ indicated considerable intermolecular coupling. Three low temperature phases have been identified in solid $SOCl_2$ (2 ordered, 1 disordered). Raman methods for the measurement of SO_2 and HCl in $SOCl_2$ have been established. Reaction of SO_2 with formamide was found to produce both S_8 and SO_4^{2-}.

The techniques of Raman, infrared, visible-ultraviolet spectroscopies, X-ray diffraction and residual gas analysis have been shown to provide complementary analytical information on the chemical processes that occur in various lithium cells. Isotope exchange studies may be used to identify the source of an impurity. Upon request these capabilities can be made available to interested workers in the field.

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FIELD OF RESEARCH / DOMAINE DE RECHERCHE
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- ☐ Environmental Toxicology / Toxicologie de l'environnement
- ☐ Open / Ouvert

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Title of Project/Titre du projet: Modeling of Subsurface Migration of Leachate From Uranium Mill Tailings

The purpose of this research was to develop a computer mixing-cell model for the simulation of transport of contaminants in groundwater derived from acidic inactive uranium tailings. Field observations of a contaminant plume emanating from the Nordic Main tailings impoundment, Elliot Lake, Ontario, were used to develop a conceptual model of geochemical reactions that occur during acidic groundwater migration. This model includes the dissolution of calcite, gypsum precipitation, and precipitation-dissolution of large amounts of Fe and Al. A specific goal was to minimize computer time utilization and thus cost by the careful choice of the processes included in the model, while maintaining the capability of simulating large amounts of mass-transfer between the solids and solution during advective groundwater flow.

Output from the model developed, ADNEUT, was compared to two existing models to verify proper operation and compare efficiency. Comparison of ADNEUT and the equilibrium speciation model WATEQ2 show only small discrepancies, arising out of the use of different methods for the calculation of activity coefficients and of speciating solutions that are not charge balanced. Comparisons between ADNEUT and a model capable of equilibrium precipitation-dissolution of solids, PHREEQE, showed ADNEUT to be more flexible, capable of reacting a greater number of solids simultaneously, and far less costly. These comparisons verify that the correct assemblage of aqueous species was selected for ADNEUT, and the model achieves its objective of calculating reliable equilibrium water chemistries for cases involving large transfers of mass between solids and solution at a low cost.

Comparisons of ADNEUT predicted solution chemistry were made with data from 3 column experiments. Results showed that, ADNEUT successfully predicted both effluent pH and duration of buffering for the case of a simple sand-calcite mixture. The model also approximated the pH and length of duration of pH buffering attributed to $Al(OH)_3$ in a column of tailings devoid of gypsum and carbonate minerals. Finally, distinct pH plateaus in the data for effluent from a column containing whole tailings compared well with model predictions of equilibrium pH values for calcite, siderite and $Al(OH)_3$, and the model produced a good estimate for the time required for elution of gypsum and $Al(OH)_3$

Data on the geochemistry of the acidic plume exiting the Nordic Main tailings impoundment were used to test the applicability of ADNEUT to a field setting. ADNEUT indicates that the plume contains three sub-regions: an $Al(OH)_3$ sub-region adjacent to the inner core, an $FeCO_3$ sub-region, and a $CaCO_3$ sub-region adjacent to the outer zone. Model predictions of retardation factors, pH, and the concentrations of major dissolved species are in general agreement with those observed in the field. Disagreements appear to be related to the limitations of ADNEUT to single value solubilities and the lack of details on some field data.

The applicability of the model is not limited to uranium tailings, and it could be applied to other cases of acidic leachate migration from other base-metal tailings.

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☐ Food-Agriculture / Alimentation-Agriculture	☐ Industrial Materials and Processes / Materiaux et procedes industriels	☐ Oceans / Oceans	☐ Open / Ouvert

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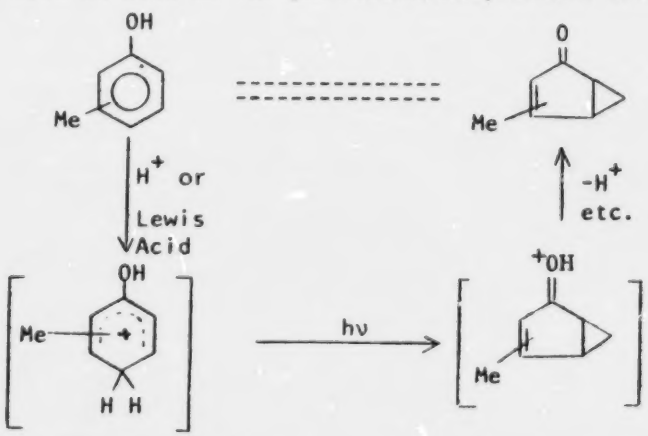
Title of Project/Titre du projet Solar Energy Storage by a Photochemical Latent Heat Approach

Summary

The overall objective of this project was to develop an organic photochemical latent heat storage system. Specifically it was proposed to base such a storage system on the valence isomerization of aromatic compounds making use of a novel acid catalysed approach to the modification of the absorption spectrum and photochemical properties of aromatic hydrocarbons. In particular it was intended to develop the use of heterogeneous acids catalysts such as the aluminosilicates (1).

In the first phase of the project it was shown that it is possible to use heterogeneous acids such as aluminosilicates and Nafion to catalyse the photoisomerizations of several organic compounds. These novel reactions were shown to proceed by adsorption of the organic material from solution onto the surface of the catalyst, modification of the chromophore by protonation or complexation of the material, photoisomerization on the surface of the catalyst, and desorption. The principles of this type of catalysis were probed and have been published (2).

The major phase of this project concerned a detailed investigation of the potential of simple alkyl phenols as candidates for a solar storage system. The cycle was based upon the conversion of a phenol to a corresponding bicyclic ketone (Scheme 1) using the cationic species to be produced by reaction with an acid as the photochemically active entities.



The quantitative aspects of the photochemical step, the total energy storage capability and reverse thermal reactions needed to release the stored energy, have all been examined in detail. The potential storage capacity of these systems is very high, and the photochemical and thermal reactions are remarkably clean and efficient. However, difficulties were encountered with the use for heterogeneous acids in the desorption step. It was found that the product was adsorbed somewhat more strongly to the acid surfaces than the starting phenols and this limits the potential usefulness of the approach to solar energy storage.

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☐ Oceans / Oceans
☐ Environmental Toxicology / Toxicologie de l'environnement
☐ Open / Ouvert

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Title of Project/Titre du projet: Strategy to Control Microbial Problems in Water Flood Oil Recovery Operations

When water is forced down an injection well, in order to displace and recover oil, this water contains variable numbers of bacterial cells and variable amounts of their organic nutrients. Bacterial growth occurs preferentially on surfaces, where cells adhere avidly and produce large amounts of extracellular polysaccharide "slime" to form an adherent biofilm. If organic nutrients are plentiful, these biofilms thicken and become visible to the unaided eye, and it is these thick masses of bacterial cells and slime that plug the injection faces of the reservoir rock and gradually decrease injectivity to the point at which the well must be treated or abandoned. If bacterial plugging is the major cause of lost injectivity, this problem can be alleviated by treatment with 5% sodium hypochlorite (bleach), as in the case of 400 wells in the Los Angeles basin. If the bore face is plugged with a mixture of particles and bacteria, sequential treatment with bleach and acid can effectively restore injectivity. The schedule for these treatments, and the effective concentrations of bleach and acid, can be established using a specific model for each set of similar wells that was developed as an AOSTRA-funded offshoot of this project.

Bacteria within these adherent biofilms may cause a much more serious form of formation damage by generating H_2S and "souring" the whole oil reservoir. Our discovery that the bacteria that generate this H_2S are will within 10 m of the bore hole is important, because once the problem is detected, this perception makes it possible to kill the H_2S-producing bacteria (SRBs) with biocides. The advent of polymer flooding and MEOR will necessitate a full microbiological understanding of the growth of bacteria in the aqueous phase of deep oil-bearing formations. This understanding will be provided by work done on this Strategic Grant and on the subsequent 1984-87 Strategic Grant entitled "Enhanced Oil Recovery by Mobility Control Using Bacterial Nutrients"

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- ☐ Environmental Toxicology / Toxicologie de l'environnement
- ☐ Oper. / Ouvert

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Title of Project/Titre du projet Energy Efficient Drives for Transit Systems

The main objectives of the Strategic Grant were to investigate and to evaluate the energy efficiency of rotary dc, rotary and linear induction, and rotary and linear synchronous motor drives for transit vehicles.

The key development in the success of this project was the implementation and improvement of a computer program capable of accepting as input recognizable and available parameters describing a transit system and computing as output useful performance characteristics which aid in the design and operation of the transit system. Energy utilization is one of the significant indicators of the effectiveness of the design and operation of the transit system. The energy management computer model consists of two primary programs, the train performance simulator and the electric network simulator.

The research activity using the program has led to the establishment of a data base for the drive systems considered. In addition, new program algorithms have been developed to improve speed and accuracy of computation of power flows in ac/dc networks.

Theoretical and experimental research work has established the characteristics and control of rotary synchronous motors for traction applications. These traction drive characteristics have been verified by experiment which puts in perspective some of the tradeoffs in the selection between dc and ac traction drive systems or between ac asynchronous and ac synchronous traction drive systems.

From a bibliography consisting of one journal paper, five conference papers and six reports, the following publications are presented:

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- ☐ Biotechnology / Biotechnologie
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- ☐ Environmental Toxicology / Toxicologie de l'environnement
- ☐ Open / Ouvert

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Le Canada a de grandes réserves de pétrole, mais ces gisements se trouvent surtout sous la forme de sable bitumineux en Alberta. Comme ces sables ne contiennent qu'environ 10% de matière organique, il n'est pas facile de récupérer économiquement ce bitume. Le but de ce projet était d'explorer la possibilité d'utiliser des microémulsions pour de telles extractions. Nos études ont démontré que ceci était possible à la condition que la microémulsion contienne un solvant organique aromatique. Le processus fonctionne aussi très bien si on extrait le sable avec des émulsions stabilisées par des quantités assez faibles de tensioactifs et de cotensioactifs. Une grande partie des travaux a porté sur la caractérisation des émulsions et des dispersions de bitume dans les microémulsions par des diagrammes de phase, des microphotographies, des mesures de tension interfaciale, de viscosité et de densité. Ces études visaient à optimiser notre procédé et à mieux comprendre le procédé d'extraction.

Une étude préliminaire a aussi été amorcée sur l'utilisation des tensioactifs comme dispersant d'huile sur l'eau de mer. Ce projet se poursuit dans le cadre d'une nouvelle subvention thématique (Océans Canada).

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☐ Open / Ouvert

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Title of Project/Titre du projet: Efficient power conditioning system (PCS) for photovoltaic arrays.

SUMMARY

The main achievement of this strategic grant has been to develop techniques to achieve an 'optimum' power conditioning system (PCS) for photovoltaic arrays as regards to performance, efficiency, weight, volume, cost and protection of arrays. The techniques developed apply to a variety of PV array applications from a few hundred watts to several kilowatts in both standing (Type A) and utility interface (Type B) applications. A variety of circuit configurations (e.g. step up chopper inverter; high frequency link HFL; line commutated inverter LCI; sinusoidally pulse width modulated SPWM inverter) have been analyzed and theoretical investigations have been verified on experimental breadboards. For the above configurations, the performance with the most recent available solid state power switches (SCR, GTO, transistor, ASCR, Hexfet) have been analyzed and compared.

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Title of Project/Titre du projet: Hybrid Photovoltaic, Photochemical Cell For Solar Energy Storage.

This project was aimed at the development of an economical system for collecting and storing solar energy as hydrogen fuel. The device for achieving this was to consist of a two junction photoelement - a photovoltaic junction (bandgap $\sim$ 1.1eV) overcoated with a wide bandgap ($\sim$ 2.0eV) oxide which was to form a photoelectrochemical junction with the electrolyte. The high energy photons absorbed in the wide bandgap material would combine with the lower energy photons absorbed at the photovoltaic junction to provide the free energy driving force to electrolyse water, O_2 being released at the oxide photoelectrode, H_2 at a counter electrode. The first step in accomplishing such a goal is the development of procedures for forming the thin films economically, and with the required excellent transport properties. This summarises our results towards this end.

As atomic sputtering is already an industrial process of some considerable importance, and is an extremely versatile method for forming a variety of thin film structures, we settled on this method and established a multitarget sputtering facility with wide ranging capabilities.

A number of different metal oxide films were formed by reactive sputtering of the metal target in an oxygen plasma, while some were formed by sputter depositing the metal films in an argon or argon-hydrogen plasma, then subjecting them to an oxygen plasma to convert them to the oxide. In every case the films formed by plasma oxidation had transport properties equal or superior to those formed by reactive sputtering, and in addition the process was about six times faster.

Photoelectrodes for oxygen evolution, made from our best iron oxide and titanium oxide films, operated with efficiencies about 80% of those achieved using the best single crystal material, efficiencies as good as or better than those obtained for polycrystalline material produced by any other technique. In some instances (CdO, In_2O_3) good photoresponse was obtained for materials that had never previously shown photoresponse in thin film form. Encouraging, but preliminary results were obtained for mixed oxides and layered oxide structures.

We conclude that atomic sputtering processes can form the basis of production of low cost, efficient, multijunction photocells, both photovolatic and photoelectrochemical.

Calculations on the potential efficiency of unbiased photoelectrochemical cells for the photoelectrolysis of water using solar radiation have led us to the conclusion that it is unlikely that such devices will reach the economic viability achievable with advanced photovoltaic cells impedance matched to electrolysis cells. Research and development in solar energy quantum conversion devices should therefore concentrate on multijunction,thin-film photovoltaics.

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Title of Project/Titre du projet: Kinetic Models for the Combustion of Methanol Fuel

The objectives of this project were to provide reaction rate data for modeling the combustion of methanol.

Currently, it is estimated that about one half of Canada's consumption of petroleum is for transportation. While the country's total energy reserves are very large, there is concern about possible supply difficulty of suitable liquid fuels for motor vehicles, even in the relatively short term. Methanol is therefore of substantial interest as a promising extender or substitute for hydrocarbons for automotive fuel. It is a liquid of suitable physical properties which forms relatively little pollutant when burned, which has good anti-knock behavior, and which can be produced in quantity from wood waste, fossil fuels, or carbon dioxide and electrolytic hydrogen. It is therefore important to consider how to use methanol effectively and economically. Computer modeling is becoming increasingly important for design of efficient combustion systems, but reliable chemical rate laws are needed. However, compared to hydrocarbons, the kinetics of methanol have been relatively little studied.

We have investigated the kinetics of pyrolysis and oxidation of methanol at high temperatures by shock tube and computer-modeling techniques. Dynamic sampling of the shock heated gases into a time-of-flight mass spectrometer gave concentration-time profiles of the reactants, products, and major reactive intermediates. Laser schlieren densitometry gave highly precise density gradient profiles of the reacting mixtures. Kinetic sensitivity analysis was used in the design of the experiments and in the evaluation of the results. A detailed mechanism and rate parameters were found which were shown to give a good representation of the pyrolysis process and of the combustion reaction under conditions appropriate to compression-ignition and ignition by flame propagation.

While it is feasible to use this detailed mechanism for quasi-one dimensional modeling, e.g. for simulating laminar flame propagation, it is currently too expensive to use it for multidimensional systems where the behavior at a large number of points on a mesh must be computed. We have therefore devised a number of simplified models of which the most promising uses a global model for initial attack and degradation of the fuel molecule, with a more detailed model of the subsequent radical-chain oxidation.

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Title of Project/Titre du projet: Thermal Energy Storage Using Cobalt/Oxygen Complexes

Summary

The storage of thermal energy by the reversible formation and decomposition of μ-peroxy cobaltate(III) complexes has been investigated. Such complexes can be formed from the corresponding Co(II) compounds by oxygenation with air at room temperature. This is an exothermic reaction. The peroxy complexes can be decomposed to the initial Co(II) compound and oxygen at temperatures around 100°C. These properties are the basis for a thermal energy storage scheme which will operate between room temperature and 100°C and which could be used in conjunction with a solar heating system. There are very few chemical systems which offer energy storage possibilities in this temperature range. There is also the added advantage of using air as the circulating material. Air is of course non-toxic and is also noncondensible. This latter property eliminates the loss of stored energy which occurs when the circulating material must be evaporated as part of the energy storage cycle.

Both chemical and engineering studies are reported. The chemical studies concentrated on the synthesis and measurement of the thermal properties of a variety of cobalt/oxygen complexes. The initial studies were directed towards complexes which could be reversibly oxygenated in the solid phase. Two such compounds were studied in some detail, bis 3-ethoxysalicylethylenediimine cobaltate(II) and the corresponding methoxy compound. These compounds show reversible oxygenation in the right temperature range and are capable of storing around 100 kJ of energy per mole of complex as measured by Differential Scanning Calorimetry. There is however some loss of activity on repeated cycling, around 33% after 90 or 100 cycles is typical, which would adversely affect the economics of the system. Some of the later research was there directed towards oxygenation reactions in aqueous solution. Side reactions leading to degradation of the compound are much less prevalent in solution. Most of this work used histidine as a ligand.

The engineering effort was directed towards the design of a fluidised bed reactor in which formation of the oxygen complex would take place at low temperatures and decomposition at higher temperatures. The use of chemically reactive materials in fluidised beds has not been common and has potential applications in areas other than energy storage. Both computer modelling and experimental work was involved in this phase of the programme. The main experimental problem encountered was the restriction on gas flow rates imposed by the small particle size of the Co complexes prepared. Later work considered the engineering problems associated with the use of solution phase reactions. It was concluded that the scheme for energy storage is feasible if a chemically suitable system can be found.

Publications and Reports

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☐ Biotechnology / Biotechnologie	☐ Communications and Computers / Telecommunications et informatique	■ Energy / Énergie	☐ Environmental Toxicology / Toxicologie de l'environnement
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Department/Departement: Electrical Engineering Department
University/Universite: Technical University of Nova Scotia
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Title of Project/Titre du projet: Modeling and Optimization for Electric Energy Systems.

This project deals with a number of important areas within Economic Operation of integrated electric power systems. Research work carried out lead to the development of new techniques for defining and selecting appropriate models of thermal generation, hydro generation, electric network and load for use in economic operation studies. Computer software was developed and tested that enables a utility to determine the optimal load sharing to minimize the cost of operation while observing constraints imposed on hydro-generation as well as network requirements.

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1. M.E. El-Hawary, and K.M. Ravindranath, "Optimal Operation of Variable-Head-Hydro-Thermal Systems Using Glimn-Kirchmayer's Model and Newton-Raphson Method", Proceedings IEE.

2. M.E. El-Hawary, and K.M. Ravindranath, "Effects of Hydro-Models on Optimal Operation of Variable-Head-Hydro-Thermal Systems", Proceedings IEE.

3. M.E. El-Hawary, and D.H. Tsang, "The Hydro-Thermal Optimal Load-Flow, A Practical Formulation and Solution Technique", Trans., IEEE on Power Apparatus.

4. El-Hawary, M.E., and Mansour, S.Y., "Performance Evaluation of Parameter Estimations Algorithms for Economic Operation of Power Systems", IEEE Trans. on Power Apparatus and Systems, Vol. PAS-101, pp. 574-582, March 1982.

5. El-Hawary, M.E., and Landrigan, J.K., "Optimum Operation of Fixed-Head Hydro-Thermal Electric Power Systems: Powell's Hybrid Method Versus Newton-Raphson", IEEE Trans. on Power Apparatus and Systems, Vol. PAS-101, pp. 547-554, March 1982.

FIELD OF RESEARCH / DOMAINE DE RECHERCHE
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☐ Biotechnology / Biotechnologie	☐ Communications and Computers / Telecommunications et informatique	■ Energy / Energie	☐ Environmental Toxicology / Toxicologie de l'environnement
☐ Food-Agriculture / Alimentation-Agriculture	☐ Industrial Materials and Processes / Materiaux et procedes industriels	☐ Oceans / Oceans	☐ Open / Ouvert

Name/Nom: Dr. I. I. Glass and Dr. J. P. Sislian
Department/Departement: Institute for Aerospace Studies
University/Université: University of Toronto
Phone number (optional)/N° de telephone (facultatif):
Title of Project/Titre du projet: Advanced modelling and diagnostics techniques in swirl combustors

The research program is mainly concerned with the comprehensive investigation of the behaviour of the turbulence properties in turbulent swirling non-combusting and combusting jets which are typical of many practical combustor flows. A sophisticated laser Doppler Velocimeter system now in operation was used to perform detailed measurements, in cold and combusting flow conditions of the following turbulence parameters: mean velocity components; all six turbulent intensities; probability-density distributions; power-spectral-density functions; auto-correlations to determine turbulence length scales. The temperature field under combusting conditions was determined by thermocouples in order to correlate high-turbulent-intensity zones with high-temperature regions. The schlieren technique was used for eddy evolution visualization and to correlate eddy size estimates with measured length scales. Finally, backscatter operation of the laser Doppler velocimeter system was explored with a view to using this mode to perform turbulent intensity measurements in a model combustion chamber of a practical small jet engine. Two turbulence models developed during this research program were incorporated into an axisymmetric turbulent recirculating flow-prediction method which was developed. The capability of in-depth analysis of turbulent flows in order to establish the appropriate turbulence prediction model can be used for a realistic simulation of practical combustor flows and hence to curtail the extremely high combustor development costs by providing design guidelines during the initial stage of combustor design.

Publications

1. Sislian, J. P., "Analysis of Swirling Jet Turbulent Mixing and Combustion", UTIAS Report No. 249, 1981.
2. Sislian, J. P. and Cusworth, R. A., "Laser Doppler Velocimetry Measurements of Mean Velocity and Turbulent Stress Tensor Components in a Free Isothermal Swirling Jet", UTIAS Report No. 281, 1984.
3. Sislian, J. P., Glass, I. I. and Jiang, L.-Y., "The Turbulence Structure of Jet Diffusion Flames", UTIAS Report No. 291, 1985.
4. Sislian, J. P., Glass, I. I. and Lu, X. K., "Computation of Swirling Axisymmetric Recirculating Free Jets and Comparison with Experimental Data. UTIAS Report, to be published in 1985.

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(Check one cocher la case appropriée)

☐ Biotechnology / Biotechnologie	☐ Communications and Computers / Telecommunications et informatique	■ Energy / Energie	☐ Environmental Toxicology / Toxicologie de l'environnement
☐ Food-Agriculture / Alimentation-Agriculture	☐ Industrial Materials and Processes / Matériaux et procédés industriels	☐ Oceans / Océans	☐ Open / Ouvert

Name/Nom: Prof. K.G. Terry Hollands
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University/Université: University of Waterloo
Phone number (optional)/N° de téléphone (facultatif): (519) 888-4053
Title of Project/Titre du projet: Application of Time-Series and Graph - Theoretic Methods to the Analysis of Solar Energy Systems".

Solar simulation is the process of simulating the performance of a solar energy system on a computer, using either real of synthetic solar radiation data as input. It is used to establish the performance of systems before they are built, to optimize systems, and to determine the feasibility of proposed projects. It is a vital part of any well-planned solar energy development programme, including that of Canada. Up to now these solar simulation programmes have operated by marching through time, hour by hour, using, as input, hourly solar radiation data from previous years at the location in question. There are several limitations to this approach, two of which are the costly computer time they require and the inflexibility of most of its programs. Although short-cut methods have been developed, they are generally inflexible and are often of questionable accuracy. Fundamental research was required before a new generation of improved programs could be launched, and this fundamental research was undertaken under this grant. Fundamental studies were carried out in three areas: statistical analysis of solar radiation data (and its application), time-series analysis of the same data (and its application), and finally the application of the graph-theoretic approach to solar simulation. This work permits the production of solar simulation computer programmes which are efficient in their use of computer time, flexible in the types of systems they can handle, and easy for the user to implement. The results of this research are being transferred to users through the WATSUN user service already in place at the University of Waterloo.

Publications:

K.G.T. Hollands and R.G. Huget, "A Probability Density Function for the Clearness Index, With Applications", Solar Energy, Vol. 30, No. 3, pp. 195-209, (1983).

"A Derivation of the Diffuse Fraction's Dependence on the Clearness Index", proceedings of the International Solar Energy Society, World Solar Congress, August 1983, now in press, Solar Energy.

K.G.T. Hollands and S.J. Chra, "An Improved Theory Relating the Diffuse Fraction to the Clearness Index", Proceedings of the 10th Annual Conference of the Solar Energy Society of Canada, August 1984, submitted to Solar Energy.

S.J. Chra, "Theoretical and Statistical Modelling of Diffuse Solar Radiation", MASc thesis, University of Waterloo, (1984).

L.J. D'Andrea, "Long Term Efficiencies of Flat Plate Solar Collector Systems", MASc thesis, University of Waterloo, (1984).

F. Hahgighat, T.E. Unny and M. Chandrashekar, "Stochastical Modelling of Transient Heat Flow Through Walls, ASME Journal of Solar Engineering, (accepted Sept. 1984).

F. Haghighat and M. Chandrashekar, "System Theoretic Models for Building Load Calculation", (submitted to ASME Journal of Solar Engineering, July 1984).

F. Haghighat, M. Chandrashekar and T.E. Unny, "Thermal Behaviour of Buildings Under Random Conditions", (submitted to Solar Energy, December 1984).

V.A. Graham, K.G.T. Hollands and T.E. Unny, "Stochastic Modeling of the Daily Atmospheric Transmittance, k_t," paper to be presented at Intersol '85 - The Biennial Meeting of the International Solar Energy Society, Montreal, June 1985.

F. Haghighat, "System-Theoretic Models for Stochastic Modeling of Physical Systems: Application to Passive Solar Buildings", Ph.D. Thesis, University of Waterloo, (1984).

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FIELD OF RESEARCH / DOMAINE DE RECHERCHE
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☐ Biotechnology / Biotechnologie
☐ Food-Agriculture / Alimentation-Agriculture
☐ Communications and Computers / Telecommunications et informatique
☐ Industrial Materials and Processes / Materiaux et procedes industriels
☒ Energy / Energie
☐ Oceans / Oceans
☐ Environmental Toxicology / Toxicologie de l'environnement
☐ Open / Ouvert

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Title of Project/Titre du projet: Aquathermolysis of Organosulphur Compounds of Heavy Oils

SUMMARY

The chemistry of the interaction between both thiophene and thiolane (model organosulphur compounds) and high temperature water was examined. The nature and amounts of the gases produced, the effect of pH and our hypothesis regarding the most likely mechanism of reaction have been published. In an attempt to optimize the beneficial effects of the reaction with water (aquathermolysis), the influence of vanadyl and nickel salts was examined. Very different effects for two vanadyl species were observed suggesting that the molecular form of the salt in aqueous solution significantly effects its participation in the aquathermolysis reaction.

Catalyst work was continued by examining the effect of aluminum and first row transition metal cations on the aquathermolysis of thiophene and thiolane (tetrahydrothiophene). The most interactive cations were those of scandium, titanium, vanadium and chromium plus aluminum and copper. Cobalt, nickel, iron, manganese and zinc were relatively ineffective; for a given cation thiophene was generally more reactive than thiolane - opposite from the behaviour in the absence of the cation. This suggests an important role may be played by interaction between the catalytic cation and the π orbital system of the thiophene. Polymerization products form a substantial part of the compounds formed. The active cations display a selectivity of 30 - 100% for desulphurization of the organosulphur compounds on aquathermolysis at 240°C.

Most recently, work included the more complex organosulphur structures represented by benzothiophene and dibenzothiophene. Aquathermolysis of these substrates in the presence of several catalytic cations has been completed. One cation has been shown to be particularly effective and extensive kinetic studies have been carried out. The general order of reactivity has been shown to be thiophene > benzothiophene > thiolane > dibenzothiophene. Data has been collected on overall percentage conversion of the substrate; % polymerization; % desulphurization and % selectivity of aquathermolytic attack.

PUBLICATIONS

1. "Aquathermolysis of Heavy Oils" - proceedings of the 2nd International Conference on Heavy Crude and Tar Sands, Vol. I, Chapter IX, February 7 - 17, Caracas, Venezuela, 1982.
2. "Steam-Oil Chemical Reactions: Mechanisms for the Aquathermolysis of Heavy Oils", AOSTRA Journal of Research, Volume 1, No. 1, September 1984.
3. "Chemistry of Organosulphur Compound Types Occurring in Heavy Oil Sands: Part 1 - High Temperature Hydrolysis and Thermolysis of Tetrahydrothiophene in Relation to Steam Stimulation Processes", FUEL, Vol. 62, No. 8, August 1983.
4. "Some Chemistry of Organosulphur Compound Types Occurring in Heavy Oil Sands: Part 2 - Influence of pH on the High Temperature Hydrolysis of Tetrahydrothiophene and Thiophene", FUEL, Vol. 63, No. 1, January 1984.
5. "Chemistry of Organosulphur Compound Types Occurring in Heavy Oil Sands: Part 3 - The Reaction of Thiophene and Tetrahydrothiophene with Aqueous Solutions of Vanadyl and Nickel Salts at High Temperatures and Pressures", FUEL, Vol. 63, December 1984.
6. "PATENT - Canadian # 1,170,444 - Use of Hydrogen-Free Carbon Monoxide with Steam in Recovery of Heavy Oil at Low Temperatures", July 10, 1984.

FIELD OF RESEARCH / DOMAINE DE RECHERCHE
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☐ Biotechnology / Biotechnologie	☐ Communications and Computers / Telecommunications et informatique	■ Energy / Energie	☐ Environmental Toxicology / Toxicologie de l'environnement
☐ Food-Agriculture / Alimentation-Agriculture	☐ Industrial Materials and Processes / Materiaux et procedes industriels	☐ Oceans / Oceans	☐ Open / Ouvert

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University/Universite: University of Waterloo
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Title of Project/Titre du projet: Studies of Electrolytes and Redox Processes of Importance in Power Research Programs

Solutions of various substances in water are an essential component of most current power-generating installations, whether they be nuclear, fossil-fueled or geothermal. The heavy water coolant leaving a CANDU reactor is at 300°C and high pressure. Process streams range up to 180°C. Temperatures in geological vaults used for storing spent fuel may be 150°C. It is important to know how such solutions behave at high temperature. The object of the research was "to gain a better understanding of the electrolyte chemistry in selected systems, the factors which are responsible for corrosion, and the equilibria important in radioactive waste management and nuclear fuel recycling."

The principle technique was Raman spectroscopy, which provides signals resulting from the vibrational modes of polyatomic species in the sample. A monochromatic beam of visible light from a gas laser is directed onto the sample and the scattered radiation is analyzed. The signals provide information concerning the identities of species, their populations and their geometries. Frequently equilibria can be identified and equilibrium constants can be measured.

Studies have been made of the following systems at temperatures ranging from 25° to 300°C: perchloric acid , nitric acid, ammonium hydrogensulfate, magnesium sulfate, iron(III) chloride, uranylchloride, lithium and sodium nitrates. In addition the adsorption of I^- to Cu has been studied by cyclic voltammetry and Raman spectroscopy.

Publications:

1 C.I. Ratcliffe and D.E. Irish, Vibrational Spectral Studies of Solutions at Elevated Temperatures and Pressures. VI. Raman Studies of Perchloric Acid. Can. J. Chem. 62 (6) 1134-1144 (1984).

2 Raman Spectral Studies of Aqueous Ammonium Hydrogensulfate Solutions to 300°C, at a Pressure of 10 MPa. D.E. Irish, B.S.W. Dawson, and G.E. Toogood, Proceedings of the IXth International Conference on Raman Spectroscopy, Tokyo, Japan, August 1984, (The Chemical Society of Japan, Tokyo, 1984) p. 780-781.

3 Surface Enhanced Raman Spectroscopy and Electrochemistry at the Copper/Iodide, Water, Interface. D.E. Irish, L. Stolberg, and D.W. Shoesmith, Surface Science, in press.

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FIELD OF RESEARCH / DOMAINE DE RECHERCHE
(Check one/cocher la case appropriee)

☐ Biology / Biologie
☐ Communications and Computers / Telecommunications et informatique
■ Energy / Energie
☐ Environmental Toxicology / Toxicologie de l'environnement
☐ Food-Agriculture / Alimentation-Agriculture
☐ Industrial Materials and Processes / Materiaux et procedes industriels
☐ Oceans / Oceans
☐ Open / Ouvert

Name/Nom: S. KALIAGUINE
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University/Université: Laval
Phone number (optional)/N° de telephone (facultatif): (418) 656-2708
Title of Project/Titre du projet: Production et valorisation d'huiles pyrolytiques à partir du bois.

Ce projet porte sur l'une des méthodes envisageables pour la liquéfaction du bois, l'extraction supercritique qui permet d'obtenir des rendements maximaux de 65 à 70% en poids du bois. Les liquides formés sont des mélanges complexes de produits de dégradation des polymères constitutifs du bois. On a étudié différents procédés catalytiques et on a conçu différents catalyseurs pour transformer une partie de ces produits en composés chimiques utiles tels par exemple les phénols alkylés, et en hydrocarbures avec pour objectif dans ce cas de produire de l'essence.

1/ Labrecque, R., Kaliaguine, S., Grandmaison, J.L. I.E.C. Prod. Res. Dev. 23, 177 (1984).
2/ Kaliaguine, S., Daniel, H., Grandmaison, J.L. Proc. 3rd Biomass liquefaction Spec. Meet., Sherbrooke, 1983.
3/ Chantal, P.. Kaliaguine, S., Grandmaison, J.L., Mahay, A. Applied Catalysis, 10, 317 (1984)
4/ Chantal, P., Kaliaguine, S., Grandmaison, J.L. in Catalysis on the Energy Scene, Studies in Surface Science and Catalysis Vol. 19, Elsevier, Amsterdam, 1984 (p. 93).
5/ Chantal, P., Kaliaguine, S., Grandmaison, J.L. soumis pour publication à Applied Catalysis.
6/ Szöghy, I., Mahay, A., Kaliaguine, S. accepté pour publication dans Zéolites.
7/ B.Nagy, J., Gabelica, Z., Kaliaguine, S., "The pentasil zeolites" in Specialist Periodical Report: Catalysis, G.C. Bond and Kemball editors, the Chemical Society, London, sera publié en 1985.
8/ Chantal, P. Mahay, A., Kaliaguine, S. Grandmaison, J.L. Proc. 5th Bioenergy R & D Seminar, Ottawa, March 1984.
9/ Grandmaison, J.L., Kaliaguine, S., Ahmed, A. Proc. 3rd Biomass liquefaction Spec. Meet., Sherbrooke, 1983.
10/ Kaliaguine, S., "Upgrading pyrolytic oils from Wood and other Biomasses". Energy Project Office, NRCC, Ottawa 1981 (130 pages).
11/ Kaliaguine, S., "Etude de faisabilité d'un procédé permettant de convertir les matériaux lignocellulosiques en carburants liquides". Rapport final, M.E.R., Québec, 1983 (68 pages).
12/ Kaliaguine, S., "Recherche d'un catalyseur optimum pour la conversion du gaz de synthèse en carburant à moteur". Rapport final, M.E.R., Québec, 1984 (75 pages).
13/ Kaliaguine, S. et Mahay, A., "Préparation et caractérisation de zéolithes de type ZSM-5". Rapport final, Canmet, Ottawa, 1984 (35 pages).

FIELD OF RESEARCH / DOMAINE DE RECHERCHE
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☐ Biotechnology / Biotechnologie	☐ Communications and Computers / Telecommunications et informatique	■ Energy / Énergie	☐ Environmental Toxicology / Toxicologie de l'environnement
☐ Food-Agriculture / Alimentation-Agriculture	☐ Industrial Materials and Processes / Materiaux et procedes industriels	☐ Oceans / Oceans	☐ Open / Ouvert

Name/Nom F.D. Manchester (Principal Investigator for Group Grant)
Department/Departement Physics and Centre for Metal Hydride Studies
University/Universite University of Toronto
Phone number (optional)/N° de telephone (facultatif) (416) 978-2978
Title of Project/Titre du projet Alloy development for hydrogen storage in the hydrogen economy

A safe, economic and reversible medium for hydrogen storage is of great importance in the development of hydrogen energy schemes. Metals which can absorb hydrogen to the level of one hydrogen atom for one metal atom are one such medium and they do have an intrinsic advantage of providing very safe storage. Alloys such as FeTi (which could be of interest to the Canadian mining industry) have shown promise as relatively cheap metals of this type (metal hydrides). These alloys store hydrogen after an 'activation' treatment, provided the hydrogen is very pure - too pure for practical utilization - so we have been attempting to find ways to enable them to accept hydrogen which contains a functional level of impurities. This requires studying surface changes in the alloy, as they depend on activation and contamination processes. We claim to have contributed to advances in the understanding of mechanisms affecting hydrogen transport through the surface layers of the FeTi family of alloys (see publications). Another branch of our program deals with the use of these alloys in hydride beds so that hydrogen can enter and leave the storage alloy rapidly. This involves studying kinetics of hydrogen absorption/desorption both theoretically and experimentally. This study has used the statistical rate theory developed by Ward & co-workers (see publications) as a basis for setting up measurements of hydrogen absorption kinetics in $LaNi_5$. Another part of our program was concerned with the use of hydrogen absorption/desorption in metal hydrides to provide control mechanisms for safety and shut-down systems for use with nuclear reactors or other systems.

Publications: (This list is abbreviated; references to other publications describing our work will be found in those publications cited here).

D. Khatamian and F.D. Manchester
"Mossbauer spectroscopy of activated FeTi. I. Products of high temperature activation". Surface Science. Accepted for publication (Dec 1984).

V. Bronca, P. Bergman, V. Ghaemmaghami, D. Khatamian and F.D. Manchester
"Hydrogen absorption characteristics of a FeTi + misch metal alloy". J. Less Comm. Metals. Accepted for publication (Sept 1984).

J.S. Hewitt, D. Khatamian, F.D. Manchester, C.A. Ward, and G.C. Weatherly
"Surface properties of hydrogen absorbing alloys used in energy conversion situations". Invited paper to be presented at Symposium on Energy Related Chemistry, Chemical Institute of Canada, June 1985, Kingston, Ontario.

D. Khatamian, G.C. Weatherly and F.D. Manchester.
"Some effects of activation for hydrogen absorption in FeTi powder". Acta. Met. 31, 1771-1780 (1983).

D. Khatamian, G.C. Weatherly, F.D. Manchester and C.B. Alcock.
"Some observations on activation of FeTi for hydrogen absorption". J. Less Comm. Met. 89, 71-76 (1983).

C.A. Ward, R.D. Findlay, M. Rizk
"Statistical rate theory of interfacial transport. I. Theoretical development." J. Chem. Phys. 76, 5599-5605 (1982).

R.D. Findlay, C.A. Ward
"Statistical rate theory of interfacial transport. IV. Predicted rate of dissociate adsorption". J. Chem. Phys. 76, 5624-5631 (1982).

C.A. Ward
"Effect of concentration on the rate of chemical reactions." J. Chem. Phys. 79, 5605-5615 (1983).

C.A. Ward, B. Farahbakhsh, R.D. Venter
"Material properties controlling hydrogen transfer into metals." Ziet. f. Phys. Chem., submitted for publication (1985).

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☐ Biotechnology / Biotechnologie
☐ Food-Agriculture / Alimentation-Agriculture
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■ Energy / Energie
☐ Oceans / Oceans
☐ Environmental Toxicology / Toxicologie de l'environnement
☐ Open / Ouvert

NOM DU BENEFICIAIRE: J.G. MARTEL
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University/Universite: du Québec
Phone number (optional)/N° de telephone (facultatif): (514) 468-7700
Title of Project/Titre du projet: "Etudes technologiques et scientifiques reliées à la fusion par confinement magnétique dans un dispositif torique"

a) Détecteurs sousmillimétriques (B.C. Gregory) - Des détecteurs ont été développés à base des diodes Schottky qui opèrent à la température ambiante. Optimisés pour 2 longueurs d'onde, 250 et 500 μm, ils ont une bonne sensibilité (~ 70 $V.W^{-1}$), un faible bruit (NEP ~ $2\text{-}7 \times 10^{-10}$ $W/Hz^{\frac{1}{2}}$ à 1 MHz) et une grande largeur de bande (continue à 10 GHz). La technologie a été transférée à MPB Technologies Inc. à Dorval. Ces détecteurs servent dans l'interférométrie et la polarimétrie des plasmas de Tokamak.

b) Fluorescence Laser (B.L. Stansfield) - Un diagnostic de fluorescence a été développé pour mesurer, avec résolution spatiale et temporelle, la concentration et la distribution des vitesses d'impuretés métalliques et de l'hydrogène atomique. L'excitation atomique est produite par le signal d'un laser à colorant accordé sur la transition voulue. La détection de la fluorescence est effectuée par un monochromateur. Le diagnostic a déjà été essayé sur le tokamak PDX (Princeton) pour l'hydrogène et sera installé sur le Tokamak de Varennes (T de V).

c) Diffusion laser CO_2 (H.W.H. Van Andel) - Un diagnostic de diffusion de la lumière à 10.6 μm d'un laser CO_2 en continu par un plasma a été développé. Les fluctuations de densité dans le plasma crée un spectre sur la lumière diffusée; l'analyse de ce spectre par une série de filtres fournit de l'information sur ces fluctuations. Le diagnostic a été monté sur le Tokamak TEXTOR (Jülich) pour étudier les fluctuations produites par diverses instabilités telles celle de dérive qui nuit le confinement. Vu le grand succès de l'expérience, le diagnostic sera monté sur T de V.

d) Interaction plasma-paroi (B. Terreault) - 5 diagnostics ont été développés pour caractériser l'état des surfaces qui ont été exposés aux plasmas ou à la radiation de flux de particules qui en sortent. Il s'agit d'un poste d'analyse de surfaces pour le T de V; l'analyse du profil d'implantation des atomes métalliques et dans certains cas l'oxygène et le carbone par la rétrodiffusion de Rutherford; la microanalyse de l'implantation de l'hydrogène dans une surface par la méthode des reculs; la désorption laser pour savoir la quantité globale d'hydrogène dans la surface; et finalement l'analyse par échange isotopique du recyclage dans un tokamak avec un spectromètre de masse. Ces diagnostics seront installés sur le T de V.

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2. C. Boucher, P. Couture, V. Fuchs, J. Geoffrion, B.C. Gregory, T.W. Johnston, J.P. Shkarofsky, M. Shoucri, B.L. Stansfield, B. Terreault, A. Vitali, "Impurity control in the Varennes Tokamak", J. Nucl. Mater. 111- 112, 332-334 (1983).
3. P. Brodeur, H.W.H. Van Andel, V.M.M. Glaude, D.C. Schram. "Experimental study of launched waves in plasma using CO_2 laser scattering". Can. Jour. of Physics 61, 1231-41 (1983).
4. D.C. Schram, H.W.H. Van Andel, G. LeClair and P. Brodeur. "CO_2 Collective scattering on moving density perturbations". Plasma Physics 25, 1133-48 (1983).
5. G. Waidmann, H.W.H. Van Andel et al. "Plasma performance, Boundary studies and first experiments with ICRH in TEXTOR". Proceed. of the 10th Int. Conf. on Plasma Phys. and Cont. Nucl. Fusion Res. London, U.K. 12-19 Sept. 1984, Paper A-III-S (1984).
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7. TFR Group and B. Terreault, "An increased understanding of gas recycling in tokamaks: Principle and application in TFR", J. Nucl. Mater, accepté (1984).

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☐ Biotechnology / Biotechnologie
☐ Food-Agriculture / Alimentation-Agriculture
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■ Energy / Energie
☐ Oceans / Oceans
☐ Environmental Toxicology / Toxicologie de l'environnement
☐ Open / Ouvert

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Title of Project/Titre du projet: Laser Fusion Research

This research program is concerned with a broad variety of issues in basic science and technology relevant to laser fusion. These range from the investigation of absorption and stimulated scattering processes occuring when high intensity laser radiation interacts with matter which can profoundly affect the efficiency of target pellet compression and fusion energy gain - to the development of a new laser for fusion research.

Considerable effort has gone into studying parametric decay processes such as stimulated Brillouin and Raman scattering (using high power CO_2 laser radiation). As a result of these and other decay processes (ion acoustic decay, oscillating two-stream instability, two-plasma decay, filamentation) large, non-equilibrium density fluctuations can be generated in a plasma under the influence of a strong electromagnetic wave. The large turbulence produced can, in turn, significantly alter basic transport properties such as absoption and thermal conductivity.

Our experimental and theoretical program has been concerned with understanding the conditions for various processes, determining non-linear saturation mechanisms, investigating techniques for reducing their effects and evaluating their consequences for plasma absorption and transport which could impact on laser fusion issues.

Insofar as it is known that short wavelength lasers are favoured as fusion drivers, we have been developing a high power krypton fluoride (KrF) laser as a facility for future laser fusion research. This is a unique Canadian program which has contributed to KrF laser science including techniques for pulse compression, to the technology base in high power excimer lasers, to UV optical sciences and to the generation of a laser/target interaction facility.

As a result of these developments a new research company, ALTECH, has been formed as a joint venture between an industrial laser company and the university to enhance laser fusion research and exploit laser and optical developments.

PUBLICATIONS

Phys. Fluids (accepted) (1984). Phys. Rev. A. (accepted) (1984). Appl. Phys. Lett. 45, 340 (1984). Rev. Sci. Inst. 55, 1084 (1984). Phys. Rev. Lett. 52, 283 (1984). Phys. Fluids 27, 589 (1984). Phys. Fluids, 26, 1071 (1983). Phys. Rev. Lett. 50, 421 (1983). J. Appl. Phys. 54, 5629 (1983). Rev. Sci. Inst. 54, 845 (1983). Opt. Lett. 8, 9 (1983). Phys. Rev. A25, 2857 (1982). Phys. Rev. A26, 1113 (1982). Phys. Rev. Lett. 49, 371 (1982). Appl. Phys. Lett. 40, 944 (1982). Physica Scripta, T2/2, 498 (1982). I.E.E.E. J. Quant. Elec. QE-18, 2048 (1982). Can. J. Phys. 60, 1247 (1982). Opt. Comm. 40, 35 (1981). Phys. Fluids, 24, 447 (1981). Modern Plasma Physics. IAEA-SMR-61/113, 437 (1981). Opt. Comm. 36, 200 (1981).

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FIELD OF RESEARCH / DOMAINE DE RECHERCHE
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☐ Biotechnology / Biotechnologie	☐ Communications and Computers / Telecommunications et informatique	■ Energy / Energie	☐ Environmental Toxicology / Toxicologie de l'environnement
☐ Food-Agriculture / Alimentation-Agriculture	☐ Industrial Materials and Processes / Materiaux et procedes industriels	☐ Oceans / Oceans	☐ Open / Ouvert

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University/Université: U. du Québec
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Title of Project/Titre du projet: Production, transport et contrôle des électrons dans les expériences d'interaction laser CO_2-matière

Les recherches entreprises dans le cadre du projet ont permis d'amener des contributions à la physique de la fusion thermonucléaire par laser. Les recherches ont permis d'étudier le transport d'énergie par les électrons suprathermiques, d'approfondir les mécanismes non linéaires (Brillouin stimulée) de l'interaction et d'analyser l'effet de l'irradiation multiraies sur les mécanismes non linéaires et la production de particules énergétiques.

Le développement de lasers multi-raies permet d'envisager l'accélération d'électrons par onde de battement. Les travaux de physique des lasers ont permis de développer des miroirs à réflectivité gaussienne afin de contrôler le mode d'émission des lasers.

Publications: plus de 30 publications de 1982 à 1984:

Choix de publications:

- N. McCarthy, P. Lavigne (1984), "Optical resonators with gaussian reflectivity mirrors: output beam characteristics", accepté pour publication dans Appl. Optics (1 nov. 1984)

- P. Lavigne, T.W. Johnston, D. Pascale, H. Pépin, M. Piché, F. Martin, R. Decoste, K. Estabrook (1984), OK, K. (1984) "Multiwavelength laser-solid target interaction at 10 microns", a été publié dans Phys. Fluids.

- F. Martin, H.A. Baldis, C.J. Walsh (1983), "Thomson scattering measurements of ion acoustic fluctuations in CO_2 laser plasma interaction". Phys. Rev. Lett. 52, 196.

- G. Picard, T.W. Johnston (1983), "Absolute Parametric Instabilities in Inhomogeneous Plasmas" Phys. Rev. Lett. 51(7), 574-77 (août)

- Nathalie McCarthy, P. Lavigne (1983). "Optical resonators with gaussian reflectivity mirrors: misalignment sensitivity". Appl. Optics, 22(17), 2704-08.

- J.P. Matte, J. Virmont (1982), "Electron heat transport down steep temperature gradients". Phys. Rev. Lett. 49 (26): 1936-39

- J.C. Kieffer, H. Pépin, M. Piché, J.P. Matte, T.W. Johnston, P. Lavigne, F. Martin, R. Decoste (1983), "Hot electron energy deposition in CO_2 laser irradiated targets consistent with magnetic field induced surface transport", Phys. Rev. Lett. 50(14), 1054-57

- J.C. Kieffer, H. Pépin, J.P. Matte, R. Decoste (1984), "Angular distribution of hot electrons incident on a laser irradiated target". Phys. Rev. A. 29, 704.

- G. Picard, T.W. Johnston (1982), "Instability cascades, Lotka Volterra equations and Hamiltonian Chaos" Phys. Rev. lett. 48(24), 1610-13

- G.R. Mitchel, B. Grek, T.W. Johnston, H. Pépin, P. Churcn, P. Lavigne, F. Martin, R. Decoste (1982), "Broadband Brillouin scatter from CO_2 laser-target interactions", Phys. Rev. Lett. 48(21), 1472-5

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☐ Biotechnology / Biotechnologie
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■ Energy / Energie
☐ Oceans / Oceans
☐ Environmental Toxicology / Toxicologie de l'environnement
☐ Open / Ouvert

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Title of Project/Titre du projet: Thermal Decomposition Modelling of Athabasca Oil Sands

The thermal decomposition of Athabasca bitumen and its fractions were studied from the point of view of enthalpy data, product yield, and kinetics.

Enthalpies were determined for oil sands, bitumen, and the bitumen-derived products light oil, medium oil, heavy oil, asphaltenes, and coke undergoing thermal decomposition in nitrogen and in air at 25-600°C and pressures up to 6-9 MPa by use of high pressure differential scanning calorimetry. Thermogravimetry was also used to provide weight loss data for correlation with the thermal data. Two regions of weight loss were detected using both gases. Increasing the pressure of nitrogen and air caused an increase in the endothermicity and exothermicity of the respective reactions.

To determine the effect of the sand matrix, Athabasca bitumen and the bitumen-derived products middle oil, heavy oils, and asphaltenes were thermally cracked in the presence and absence of sand at 360, 400 and 420°C. The products were separated into the fractions gases, light oils, medium oils, heavy oils, asphaltene and coke. The yields of coke and gases from cracking bitumen-sand mixtures were higher than from cracking bitumen by itself. The yields of other products also differed. The energies of activation for reactions involved in cracking bitumen-sand mixtures were lower than those for reactions in the absence of sand. Two kinetic models were developed to describe the system. The models used incorporated either four pseudo-components (coke, asphaltenes, heavy oils, distillables [a combination of gases, light oils and middle oils]) or the full set of six pseudo-components. Both models were able to fit the product yield vs time data well.

The oxidation reaction kinetics of bitumen from Athabasca oil sands were investigated in a flow-through fixed bed reactor using gas mixtures of various compositions. The system was modelled as an isothermal integral plug-flow reactor. The oxidation of bitumen was found to be first order with respect to oxygen concentration. Two models were examined to describe the kinetics of bitumen oxidation. The first reaction model assumes that the bitumen is oxidized in a single irreversible reaction over the temperature range studied. The second model assumes that bitumen is a single reactant and that the oxidation of bitumen may be described by two simultaneous, parallel reactions, one producing oxygenated hydrocarbons and water, the other producing CO and CO_2.

The thermo-oxidative reactions and thermal cracking reactions of Athabasca bitumen were also examined both qualitatively and quantitatively using the technique of differential thermal analysis (DTA). Reaction kinetics of low temperature oxidation (LTO) and high temperature cracking (HTC) were determined. All DTA thermograms were studied qualitatively with emphasis on the separation of low temperature oxidation (LTO) and high temperature oxidation (HTO) peaks. The changes in peak shape, peak width and reaction onset temperature were determined under the various experimental conditions outlined above. A conclusion of relevance to thermal in situ processes is that heating rate can be used effectively to control the amount of low temperature oxidation and hence fuel availability during in situ combustion.

Product yields and kinetics were studied in the hydrocracking of Athabasca bitumen and asphaltenes. Instead of the gases, light oil, medium oil, heavy oil, asphaltene, and coke fractions, the products were determined as asphaltenes, resins I, resins II, saturates, aromatics determined according to the Syncrude Analytical Methods, and coke and gases. Detailed gas analyses were also made. Hydrocracking of Athabasca bitumen without catalysts and in the presence of various catalysts was carried out both with and without promoters such as Co and Mo. The reaction conditions were 375, 400 and 420°C, 7.2 MPa initial hydrogen pressure.

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FIELD OF RESEARCH / DOMAINE DE RECHERCHE
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- ☐ Environmental Toxicology / Toxicologie de l'environnement
- ☐ Open / Ouvert

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Title of Project/Titre du projet: Saccharification of biomass by vacuum pyrolysis and acid hydrolysis.

SUMMARY

The main objective of the project is to study the pyrolytic saccharification of complex biomass (e.g., wood) for the production of ethanol. The strategy used is an alternative to the direct acid or enzymatic hyrolysis of cellulosic materials.

Previous fundamental studies conducted at the bench scale unit in U.S.A. have indicated that pyrolysis under reduced pressure of pure cellulose produced materials that are readily hydrolyzable (e.g., levoglusosan) into substances which could potentially be fermented into ethanol. Our proposal was to investigate the conversion of various lignocellulosic materials into ethanol via the pyrolytic saccharification in a large scale unit.

The overall approach involved the vacuum pyrolysis of various cellulosic materials as well as softwood and hardwood species in a large, semi-continuous multiple hearth furnace. The pyroligneous liquors derived from biomass were characterized and hydrolysed under acidic conditions. Enzymatic hydrolysis of the tars was alternatively attempted. High yields of D-glucose in the range of 13% w/w (wood moisture-ash-free bases) have been obtained.

Both the direct fermentation of the tars and fermentation of the hydrolysed liquors was attempted. Saccharomyces cerevisiae No. 23 was the most succesful yeast found. However the ethanol production was partially inhibited by unidentified chemicals present in the pyroligneous liquors.

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- Roy, C., A. Lalancette, B. de Caumia, D. Brouillard, P. Rivard and B. Côté. "Production of oils and chemicals by vacuum pyrolysis of wood". 34th Canadian Chemical Engineering Conference. Québec, Qué. September 30 - October 3, 1984. pp. 412-415.

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FIELD OF RESEARCH / DOMAINE DE RECHERCHE
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☐ Oceans / Oceans
☐ Environmental Toxicology / Toxicologie de l'environnement
☐ Open / Ouvert

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Title of Project/Titre du projet: Etude de la radioactivité naturelle dans le fleuve St-Laurent et ses affluents

Nous avons utilisé deux méthodes d'échantillonnage mis au point dans nos laboratoires pour étudier la radioactivité naturelle dans le fleuve St-Laurent et ses affluents. L'une des méthodes consiste à recueillir les boues d'alun dans les usines de traitement d'eau potable, l'autre consiste à recueillir des dizaines de grammes de matière en suspension à l'aide d'un filtre au sable du type de ceux utilisés pour les piscines. Ces deux techniques ont été décrites en détails dans les deux publications suivantes: a) Analusis 12, no 9, 448-461, 1984 et b) Water Poll. Res. J. Canada, numéro spécial sur la radioactivité, décembre 1984.

La mesure de la radioactivité naturelle s'est faite par spectroscopie gamma à haute résolution et comprend les radionucléides suivants: U-238, U-235, Ra-226, Ra-228, Th-228, Pb-210, K-40 et Be-7.

Nous avons montré qu'il est indispensable de connaître la quantité de matière en suspension dans les eaux au moment du prélèvement pour interpréter les concentrations des radionucléides et leurs variations au cours du temps. Nous avons mesuré la radioactivité naturelle en fonction de la concentration de la matière en suspension sur une période de plusieurs années pour les cours d'eau suivants: le fleuve St-Laurent, au niveau de Québec, Bécancour et St-Lambert, la rivière Chaudière, au niveau de Charny, la rivière St-Maurice, au niveau de Trois-Rivières, la rivière Richelieu, au niveau de Sorel. La fréquence des échantillonnages a été en moyenne de 5 à 12 par année pour chaque site d'échantillonnage et a été en fonction inverse de l'éloignement du site par rapport à nos laboratoires. Les résultats obtenus permettent d'examiner l'influence de différents facteurs sur le niveau de radioactivité naturelle; en plus de la matière en suspension qui est de beaucoup le facteur le plus important, nous avons commencé à examiner l'influence de la géologie du bassin versant et de facteurs climatologiques comme la crue des eaux, les débacles, les saisons et ainsi de suite. Nous avons conçu un modèle et calculé la quantité de radionucléides transportés par le fleuve St-Laurent et ses affluents vers l'estuaire. Nous avons calculé dans quelques proportions se distribuent les radionucléides sur les constituants suivants de la matière en suspension: les carbonates, les oxydes de fer et de manganèse, la matière organique et le résidu.

Ce projet nous a amené à reexaminer les schémas de désintégration de U-238 et Th-238; nous avons identifié pour la première fois les radiations à 63.9 et 140.8 keV du Th-232 et celle à 113.5 keV dû à U-238.

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☐ Environmental Toxicology / Toxicologie de l'environnement
☐ Open / Ouvert

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Title of Project/Titre du projet Fusion Research with STOR-1 and STOR-M

One of the main problems in the magnetic containement approach to controlled fusion is the production of a sufficiently high temperature ($\sim 10^8$ °K) for ignition of the ionized deuterium and tritium fuel (plasma). In order to reach this temperature in a toroidal system of the tokamak type - the leading contender at present - some form of supplementary heating is required in addition to the ohmic heating provided by the tokamak current. Turbulent heating is/will be investigated as a possible supplementary heating scheme in the tokamaks STOR-1M (operating)/STOR-M (under construction). This method consists of passing a large current density through the plasma to generate fluctuating particle densities and electric fields which in turn present a large electrical resistance to the current flow and result in rapid heating. Since it began operation in Nov., 1983, STOR-1M (with major/minor radii of the doughnut-shaped plasma of 22cm/3.5 cm, toroidal magnetic field of $\leq$15 kG) has been used mainly to demonstrate, for the first time, the possibility of operating a tokamak in an ac manner. AC operation may provide a means of continuously operating an eventual tokamak reactor. In any case the problem of current reversal seems to be less serious than anticipated. Turbulent heating studies are now commencing with STOR-1M and will be continued with STOR-M (major/minor radii of 46 cm/13 cm, turbulent heating current of 100 kA for 50 μs superimposed on a tokamak current of 60 kA) upon its completion by about mid-1985.

List of Publications (1981-84):

G. Ahmadi and A. Hirose, "Distortion of Velocity Gradient by Anomalous Viscosity", Plasma Science 9, 21 (1981).
O. Ishihara, A. Hirose and A.B. Langdon, "Nonlinear Evolution of Buneman Instability", Phys. Fluids 24, 452 (1981).
O. Ishihara and A. Hirose, "Quasilinear Mechanism of High Energy Ion Tail Formation in Ion Acoustic Instability", Phys. Rev. Letters 46, 771 (1981).
O. Ishihara and A. Hirose, "Nonlinear Evolution of Lower Hybrid Drift Instability", Phys. Fluids 25, 171 (1982).
A. Hirose, O. Ishihara and A.B. Langdon, "Nonlinear Evolution of Buneman Instability II - Ion Dynamics", Phys. Fluids 25, 610 (1982).
A. Hirose and O. Ishihara, "Quasilinear Evolution of Ion Acoustic Instability in Magnetic Field", Proc. Int. Conf. Plasma Phys. (Göteborg, Sweden, 1982) p. 423.
O. Ishihara and A. Hirose, "High Energy Ion Tail Formation in Ion Acoustic Instability - Three Dimensional Quasilinear Approach", Phys. Fluids 26, 100 (1983).
C. Boucher, A. Hirose, H. Kuwahara, A.H. Morton, H.M. Skarsgard, Y. Watanabe and S. Wolfe, "Turbulent Heating Studies in STOR-1", Can. J. Phys. 61, 147 (1983).
O. Ishihara and A. Hirose, "Quasilinear Evolution of Current Driven Ion Acoustic Instability in a Magnetic Field", Phys. Rev. Lett. 50, 1783 (1983).
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A. Hirose, "On Upconversion of Ion Acoustic Wave to Langmuir Wave", Comm. Plasma Phys. and Controlled Fusion 8, 117 (1984).
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O. Ishihara and A. Hirose, "On Validity Range of Quasilinear Theory:, Comm. Plasma Phys. and Controlled Fusion, 8, 229 (1984).
O. Mitarai and A. Hirose, "Model Circuit Analysis for the Current Drive Operation in a Tokamak", Nucl. Fusion 24, 481 (1984).
O. Ishihara and A. Hirose, "Frequency Shift of Coherent Ion Acoustic Waves in the Presence of Ion Acoustic Turbulence", Phys. Fluids 27, 2429 (1984).
A. Hirose, K. Sawada and S. Miyoshi, "Electrostatic Instability Due to Axially Nonuniform E × B Rotation in Tandem Mirrors", J. Phys. Soc. Japan 53, 3284 (1984).

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FIELD OF RESEARCH / DOMAINE DE RECHERCHE
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Title of Project/Titre du projet: Tritium Retention in Fusion Reactor Materials

One of the major streams of the Canadian Fusion Effort is centered on fusion fuels (^2D and ^3T) and associated technology. The program, entitled "Canadian Fusion Fuels Technology (CFFTP)", was established in 1982 with joint funding provided by the Governments of Canada and Ontario and Ontario Hydro, with the aim of exploiting and building on Canada's unique experience with D and T gained from the CANDU fission program. The CFFTP is under the management of Ontario Hydro.

Our fusion group at UTIAS participated in the NRC-sponsored study that led to the establishment of CFFTP, and we have formulated our research objectives to contribute in a significant way to the overall goals of CFFTP. Our objectives are two-fold: (1) generation of scientific/engineering data and understanding regarding tritium related processes in the fusion environment, and (2) the provision of trained manpower for the CFFTP program. With respect to the former, our specific goals include: (i) scientific research, (ii) testing of engineering materials for present day and future fusion devices, (iii) research/testing in a tritium facility, and (iv) development of new materials for fusion (and possibly spin-off) applications.

The focus of our current research at UTIAS is on the interaction of first wall materials with the fusion plasma. In our studies we expose candidate materials to controlled fluxes of plasma particles (H^0, H^+, e^-, etc.) and investigate phenomena such as wall erosion, hydrogen retention and permeation. Our work in this area commenced prior to the establishment of CFFTP; in fact, we have started in 1978 with an NSERC strategic grant and support from the Ontario Ministry of Energy. A subsequent NSERC Strategic Grant (1981-1984) and CFFTP support since 1982 enabled us to build up unique fusion plasma simulation facilities which have enabled us to obtain results that are needed by the international fusion effort. A list of publications resulting from our work is given below:

1. O. Auciello, A. A. Haasz, P. C. Stangeby, P. R. Underhill, "Electron Assisted Methane Production of Carbon Surfaces", Ninth Symp. on Engineering Problems of Fusion Research, Chicago, Oct. 26-29, 1981, IEEE Pub. No. 81CH1715-2 NPS (1981), pp. 252-254.
2. A. A. Haasz, P. C. Stangeby, O. Auciello, J. Nucl. Mater. 111 & 112 (1982), pp.757-762.
3. P. C. Stangeby, O. Auciello, A. A. Haasz, J. Vac. Sci. & Technol. A1 (1983), pp.1425-1429.
4. O. Auciello, A. A. Haasz, P. C. Stangeby, Fusion Technology (1984), pp. 411-413.
5. O. Auciello, A. A. Haasz, P. C. Stangeby, J. Vac. Sci. & Technol., A2 (1984), pp.630-633.
6. O. Auciello, A. A. Haasz, P. C. Stangeby, Phys. Rev. Lett., 50 (1983), pp. 783-786.
7. A. A. Haasz, O. Auciello, P. C. Stangeby, I. S. Youle, J. Nucl. Mater. 128 & 129 (1984), pp. 593-596.
8. O. Auciello, A. A. Haasz, P. C. Stangeby, "Synergism in Materials Erosion Due to Multi-species Impact", Workshop on Synergistic Effects in Surface Phenomena Related to Plasma Wall Interactions, Nagoya, Japan (May 21-23, 1984); Radiation Effects (In press).
9. P. C. Stangeby, O. Auciello, A. A. Haasz, B. L. Doyle, J. Nucl. Mater., 123 (1984), pp. 1592-1597.
10. J. W. Davis, A. A. Haasz, O. Auciello, P. C. Stangeby, B. L. Doyle, J. Nucl. Mater., 128 & 129 (1984), pp. 788-791.
11. A. B. Antoniazzi, A. A. Haasz, O. Auciello, P. C. Stangeby, J. Nucl. Mater., 128 & 129, (1984), pp. 670-675.
12. C. S. Pitcher, O. Auciello, A. A. Haasz, P. C. Stangeby, J. Nucl. Mater., 128 & 129 (1984), pp. 597-600

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FIELD OF RESEARCH / DOMAINE DE RECHERCHE
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Title of Project/Titre du projet: 'Synthetic Lube Oils. Facilitation of Nucleophilic Addition to Polyaromatics by Metal Complexation'.

STRATEGIC GRANT #G0724
'Synthetic Lube Oils. Facilitation of Nucleophilic Addition to Polyaromatics by Metal Complexation'.
S.R. STOBART, Dept. of Chemistry, University of Victoria, B.C. Canmada V8W 2Y2.

Summary of Achievements Summarizing the impact of the results on the area of the original proposal, it has been shown that activation of hydroaromatic molecules (e.g. tetralin, octahydroanthracene) by complexation at transition-metal centers (e.g. Fe or Mn in cationic organometallic compounds) can be used for structural modification of hydrocarbon skeletons leading to increased C:H ratio via the operations conceived as project objectives (i)-(iii), viz hydrogenation, selective C-C bond-cleavage, alkylation. Important conclusions of the research include the following: (a) the classical view of $AlCl_3$ as a passive component in synthetic hydrocarbon-transition element chemistry is incorrect; (b) $AlCl_3$ can promote hydrogenation and skeletal rearrangement of polyaromatic molecules in solution in inert solvents under unexpectedly mild conditions; (c) alkylation of coordinated hydroaromatics may be effected regioselectively within the aromatic nucleus and stereoselectively α to the aromatic nucleus via eqs 1 and 2; (d) sequential nucleophilic addition to the aromatic nucleus is possible via hydride abstraction; (e) complete alkylation of sites α to the aromatic nucleus is possible in a single synthetic step unless steric restrictions become very severe. At the same time it has become clear that some serious difficulties lie in the way of future progress relying uniquely on the approach adopted: these include (a) lack of economically attractive substrates for use as nucleophiles/electrophiles in eqs 1, 2; (b) stoichiometric nature of the model metal-mediated transformations developed, although catalytic recycling may be feasible via chemically- or photochemically-induced arene-exchange reactions.

S.R. Stobart and M.J. Zaworotko. Influence on Transition-metal-Arene Complex Formation of Hydrogenation and Rearrangement of Polyaromatic Substrates induced by Aluminium Trichloride. Octahydrophenanthrene Complexes from Tetralin: X-Ray Crystal Structure of η^5-1,2,3,4,5,6,7,8,9-endo-nonahydro-9-exo-methylphenanthrenyl(tricarbonyl)manganese. J. Chem. Soc., Chem. Commun. 1984

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- ☐ Environmental Toxicology / Toxicologie de l'environnement
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Title of Project/Titre du projet: "Organic Geochemical Studies of Canadian Crude Oils"

The organic geochemistry of the Alberta oil sands, heavy oils and carbonate bitumens has been investigated in detail. Hundreds of individual molecules have been detected, many of them for the first time, and their structures established. These include cyclic terpenoid hydrocarbons, sulfides, sulfoxides and carboxylic acids, fluorenes, fluorenols and fluorenones, each occurring in homologous series. The distribution of biological markers suggests a common origin for the oil sands, Lloydminster heavy oil and Carbonate Triangle bitumens.

A complex mixture of non-bitumen-like material chemisorbed to the mineral matrix has been detected in the oil sands, containing humic, fulvic and monocarboxylic acids, as well as other compounds. The acids, where present in high concentrations, can render the mineral surface oil wet and thereby adversely influence the separability of the bitumen in the hot water process. A fraction of these acids can also solubilize in the hot water and accumulate in the tailing pond where it can cause settling problems.

The presence of these an other natural surfactants in the bitumen, such as cyclic terpenoid sulfides, sulfoxides and carboxylic acids, most likely play a hitherto not well recognized role in the in situ recovery of bitumen from the reservoir.

Two major classes of compounds, the sulfides and the fluorenes, comprising several percent of the bitumen, have been identified as being largely responsible for the aging and oxygen uptake in air exposed oil sands.

PUBLICATIONS ARISING FROM THE PROGRAM: 1) "Detection of Methyl Fluorenones in Athabasca Oil Sand Bitumens", Org. Geochem., submitted Jan 25/85; 2) "A Field Ionization Mass Spectrometric Study of the Maltene Fraction of Athabasca Bitumen - Part III - The Polars", AOSTRA J. Res., accepted Feb 6/85; 3) "The Identification of 9-n-Alkyl Fluorene-9-ols in the Alberta Oil Sands", Org. Geochem., accepted Sept 13/84; 4) "A Field Ionization Mass Spectrometric Study of the Maltene Fraction of Athabasca Bitumen - Part II - The Aromatics", AOSTRA J. Res., accepted July 12/84; 5) "A Field Ionization Mass Spectrometric Study of the Athabasca Bitumen - Part I - The Saturates", AOSTRA J. Res., accepted July 12/84; 6) "Identification of Bicyclic Terpenoid Hydrocarbons in the Saturate Fraction of Athabasca Oil Sand Bitumens", Org. Geochem., accepted Apr 12/84; 7) "Bound Carboxylic Acids in the Alberta Oil Sands", Org. Geochem., 7, 127-140 (1984); 8) "High Temperature Pyrolysis of Petroleum Asphaltenes", AOSTRA J. Res., 1, 127-137 (1984); 9) "Specific Problems in the Upgrading of Alberta Oil Sand Bitumen - An Overview of its Characteristic Composition and Structure", J. Japan Petrol. Inst., 27, 89-100 (1984); 10) "The Structures of Tricyclic Terpenoid Carboxylic Acids and their Parent Alkanes in the Alberta Oil Sands", J. Chem. Soc., Chem. Commun., 1028-1030 (1983); 11) "Enrichment of Polycyclic Terpenoid Saturated Hydrocarbons from Petroleum by Adsorption on Zeolite NaX", J. Chromatogr., 270, 219-225 (1983); 12) "Tricyclic Terpanes in the Athabasca Oil Sands: Their Geochemistry", Advances in Organic Geochemistry, Eds. M. Bjorøy et al., Wiley Heyden, London, England, 1983, pp. 746-766; 13) "The Influence of Bitumen Structure on Recovery and Upgrading", Proceedings of Pan-Pacific Synfuels Conference, The Japan Petroleum Institute, Tokyo, 1982, Nov 17-19, Vol. II, 731-738; 14) "Novel Terpenoid Sulfoxides and Sulfides in Petroleum", Tetrahedron Lett., 24, 651-654 (1983); 15) "Advances in the Chemistry of Alberta Tar Sands: Field Ionization Gas Chromatographic/Nass Spectrometric Studies", Atomic and Nuclear Methods in Fossil Energy Research, Eds., R.H. Filby, B.S. Carpenter, R.C. Ragaini, Plenum Publishing Corp., New York, N.Y. 1982, pp. 409-441; 16) "18,19-Bisnor-13βH,14αH-Cheilanthane: A Novel Degraded Tricyclic Sesterterpenoid-Type Hydrocarbon from the Athabasca Oil Sands", Tetrahedron Lett., 23, 2711-2714 (1982).

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☐ Biotechnology / Biotechnologie ☐ Communications and Computers / Télécommunications et informatique ■ Energy / Énergie ☐ Environmental Toxicology / Toxicologie de l'environnement
☐ Food-Agriculture / Alimentation-Agriculture ☐ Industrial Materials and Processes / Matériaux et procédés industriels ☐ Oceans / Océans ☐ Open / Ouvert

RECEIVED REÇU
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University/Université: University of Toronto
Phone number (optional)/N° de téléphone (facultatif): 978-6901
Title of Project/Titre du projet: Grinding and Beneficiation of Coal -- G1234

P It is possible to replace oil in utility and industrial boilers with coal slurry fuels. To do this effectively, the coal must be ground very fine and its ash and sulfur content must be reduced. The spherical agglomeration technique developed at the National Research Council (NRCC) is an excellent method for such coal cleaning (beneficiation), and for recovering very small coal particles. The finely ground coal, dispersed in water, is contacted with oil by intensive mixing. The oil bridges between the hydrophobic coal particles to form the agglomerates which are then separated from the aqueous phase by screening.

This process has been simplified by combining the grinding and agglomeration steps such that the excess grinding energy is used for mixing and agglomeration. Experiments with the Szego mill, a novel planetary ring-roller mill which is able to handle the pasty agglomerates, have shown that ash removal from Minto (New Brunswick) coal is comparable to that obtained with the usual NRCC process. The generally flaky products of the Szego mill allow better ash liberation, and the presence of oil enhances grinding performance. Favourable oil-coal-water ratios have been established. Different roller groove combinations have been used; ash removal is closely related to the grinding performance of the mill. Oil has been injected at different positions in the mill so as to study the effect of agglomerate residence time on the process.

Mill performance has been modelled for both wet and dry grinding. The theoretical approach combined with some experimental results permits systematic prediction of grinding performance at different conditions and with different feed sizes, important for the design of mill/classifier systems.

The economics of coal beneficiation for the preparation of coal-slurry fuels appears attractive particularly when beneficiated coal from mine washery waste streams can be used, an operation now being pioneered by the NRCC. The same applies to the recovery of usable coal from mine tailings ponds. The simultaneous grinding and agglomeration in the Szego mill constitutes a process improvement which significantly reduces both capital and operating costs.

While use of coal-slurry fuels is still modest, several large-scale demonstrations are going on, both in Canada and elsewhere. At least one large, 400 MW utility boiler has been converted to burn a coal-oil mixture fuel, and several industrial boilers use coal-oil or coal-water slurries. Interest is high, as witnessed by attendance and papers at the recent International Coal Slurry Combustion and Technology Symposia. It is hoped that the improved coal beneficiation process will give a further impetus to the strategicly important and economically attractive conversion from oil to coal-oil-water slurry fuels.

Publications:

1. Koka, V.R., and Trass, O., "Analysis of the Kinetics of Coal Breakage by Wet Grinding in the Szego Mill", Proceedings 33rd Canadian Chemical Engineering Conference, Vol. 2, Toronto, Ont., 1983.
2. Koka, V.R. and Trass, O. "Breakage Kinetics Using Multi-pass Grinding" 15th Ann. Mtg. of the Fine Particle Society, Orlando, FL, Aug. 1984.
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4. Trass, O. and McCracken, T.W., "Grinding and Oil Agglomeration of Coal in the Szego Mill" 4th Intl. Symp. on Agglomeration, Toronto, Ont., June 1985.

Patent Application

Trass, O., "Method of Separating Solids by Simultaneous Comminution and Agglomeration", U.S. patent application No. 622340, filed June 19, 1984.

☐ Biotechnology / Biotechnologie
☐ Food-Agriculture / Aliment — Agriculture
☐ Communications and Computers / Telecommunications et informatique
☐ Industrial Materials and Processes / Materiaux et procedes industriels
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☐ Oceans / Oceans
☐ Environmental Toxicology / Toxicologie de l'environnement
☐ Open / Ouvert

RECEIVED REÇU
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Title of Project/Titre du projet: Coal and Heavy Oil Processing in a Grinder-Reactor

The major objective of this one-year strategic grant was to prove the concept of the enhancement of reaction rates by in-situ fresh surface and active site generation caused by mechanical grinding of coal in hydrogen-donor media.

We have proposed a first, feasibility test program for a potentially economical, coal liquefaction/oil upgrading process. Current technology requires that hydrogenation take place at very severe conditions, i.e., high temperatures and pressures. These translate into high processing costs. The cost of a specific catalysts, in view of rapid irreversible poisoning, can also be exhorbitant. It is expected that the proposed process will help ameliorate both problems, by allowing operation at lower temperatures and pressures, and using cheap, disposable catalysts.

Our proposal relied on the so-called 'mechano-chemical' effect, that grinding a polymeric solid material will significantly enhance its reactivity. Balancing this with other rate-determining steps in the total hydrogenation process should allow the major benefits referred to above. For grinding, it was proposed to utilize the novel Szego mill which allows close control over most parameters which are likely to be important for process design. As the mill can also be adapted to high-pressure operation, it is most suitable for this application. A brief description follows.

The Szego mill is a planetary ring-roller mill. It consists principally of a stationary, cylindrical grinding surface inside which a number of helically grooved rollers rotate, being suspended by flexible shafts form flanges connected to a central drive shaft. The material is fed by gravity, or pumped into a top feed cylinder and is discharged at the bottom of the mill. The particles, upon entering the grinding unit, are repeatedly crushed between the rollers and the stationary grinding surface. The crushing force is created mainly by the radial acceleration of the rollers. An important feature is the ability of the roller grooves to aid transport of the material through the mill, thus providing a means to control residence time and mill capacity.

Progress made on this project includes,

(1) upgrading an existing autoclave and building a special, small Szego mill to fit into it.
(2) a series of preliminary experiments to test and refine the equipment and to establish the experimental procedures.
(3) two successful, comparative experiments, one with grinding and the other with stirring only, under otherwise similar conditions. Bituminous coal in tetraline was used, with no catalyst added. The operating pressure was 13 MPa (2000 psi) temperature 340°C and reaction time 50 minutes.

The results from the comparative experiments show higher conversion and lighter products for the grinding experiment, with an oil and gas yield about twice that for the experiment with stirring only. Total conversions were 28 and 24 per cent, respectively. These low values can be increased by raising the temperature and adding catalytic mineral matter such as iron compounds. The small mill with its simplified design showed no sign of wear, suggesting that the redesign may be successful.

While additional, confirmatory experiments are essential, one can reach the tentative conclusion that the concept of enhanced reaction rates brought on by grinding and the resultant fresh surface generation is, at lease qualitatively, correct.

Canada imports large quantities of crude oil, yet the major energy projects have been cancelled or postponed. There is a need, for both economic and strategic reasons, to convert more of Canada's indigenous fossil fuel supplies to light oil quality. Economically sound processes to upgrade our heavy oils and to liquefy coal may provide some answers. We hope that this project, by bringing in novel technology as described above, can make an eventual contribution to such an economical upgrading/liquefaction process.

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FIELD OF RESEARCH: Energy

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TITLE OF PROJECT: Bivalent Heat Pumps with Storage;
I Agricultural Application to Greenhouse Heating

Project Summary:

Energy consumption for space heating costs commercial greenhouse operators approximately 200,000 dollars per hectare annually. This represents about 30 percent of the annual operating costs and provides substantial incentives for the adoption of energy conserving technologies.

A bivalent heating system, consisting of water source, air sink heat pumps and central oil-fired boilers, has been studied. Ten (10) heat pump units are distributed throughout a greenhouse which covers 1500 m^2. The use of multiple units permits cost reductions by decreasing the complexity of the required heat distribution system. It also allows domestically manufactured equipment to be employed.

A literature survey was conducted to determine the characteristics of the heating plant/structure system that are relevant to energy consumption and financial analyses.

The greenhouse structure's energy demand characteristic was determined from daily fuel use data supplied by the operator. This was related to meteorological conditions recorded at the nearest Environment Canada weather observation station. Consideration was given to the effect that the diurnal variation in heating load has upon predicted energy consumption and cost.

A computer algorithm was developed to predict heating energy consumption on a monthly basis. This permits consideration of the effect that part year cultivation has on energy consumption. It also allows calculation of the actual electric energy costs based upon the monthly consumption. This prediction was used, along with assumed fuel price escalation rates and investment costs, to determine the total annual dollar savings generated by the system. These savings demonstrate a well defined optimal level for investment.

A 41 percent reduction in energy costs and a 70 percent reduction in oil consumption have been demonstrated. These confirm the predictions of the energy analysis algorithm, which are 40 and 67 percent respectively.

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[3] Tunc, M., Venart, J.E.S. (1984). "Unsteady Thermal Behavior of the Greenhouse Environment." Int. Comm. Heat Mass Transfer, V. 11, pp. 251-266.

FIELD OF RESEARCH / DOMAINE DE RECHERCHE
(Check one/cocher la case appropriee)

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- ☐ Food-Agriculture / Alimentation-Agriculture
- ☐ Communications and Computers / Telecommunications et informatique
- ☐ Industrial Materials and Processes / Materiaux et procedes industriels
- ■ Energy / Energie
- ☐ Oceans / Oceans
- ☐ Environmental Toxicology / Toxicologie de l'environnement
- ☐ Open / Ouvert

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Title of Project/Titre du projet: Engineering Development of a Canadian Fuel Cell Technology

A significant research and development capability in KOH fuel cells using pure hydrogen has been developed within the Laboratory of Advanced Concepts in Energy Conversion within the Department of Mechanical Engineering at the University of Toronto. The particular emphasis of the research and development undertaken include:

a) the preparation of electrocatalysts and dispersion of these catalysts on selected substrates, i.e. Nobel metals/Raney nickel on carbon or porous nickel substrates.

b) the development of manufacturing methods by which electrodes can be produced to required specifications i.e. Pt loading, wetting characteristics, etc. at comparatively low cost.

c) the establishment of comprehensive test facilities to ascertain the electrochemical performance characteristics of fuel cell electrodes in both half cell, full cell and stack arrangements.

d) the development of analytical models to predict the performance of the 'ideal' fuel cell. The model incorporates fundamental electrochemical parameters and provides an assessment of the projected performance in relation to the important design parameters of electrode spacing, internal resistance, etc. as they pertain to peak power operation and efficiency of the cell.

e) the development of fuel cell stack systems having a maximum cell area of 160 cm^2. The stacks are of bipolar design and structured such that the external manifold system for the gaseous reactants (hydrogen and oxygen) are an integral component of the bipolar plates. The bipolar plates are fabricated from new conductive plastic materials, are therefore of lightweight and serve to support the collection of current produced within the cell.

At the present time electrodes produced by Pt catalyst dispersion on a carbon substrate with a Pt loading as low as 0.2 mg/cm^2 have been demonstrated to operate very satisfactorily at lifetimes up to 1000 hours. Fuel cell stacks with a surface area of 160 cm^2 are being tested using these electrodes. A particular feature of these cells is the use of conductive plastic materials in the bipolar plate construction. Projected power outputs for four cell stacks are in the 60-100 watt power range.

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2. Weber, M.F., Pataki, L., Venter, R.D. and Dignam, M.J. "Sputtered Fuel Cell Electrodes", Proceedings of the 5th World Hydrogen Energy Conference, Toronto, Pergamon Press, Vol. 4, pp. 1685-92 (1984).

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4. Park, S.-M., Aruliah, S., Ho, S., Weber, M.F., Ward, C.A. and Venter, R.D. "Electrochemical Reduction of Oxygen Studies by Rotating Ring-Disk Electrode Techniques in KOH Solution", Extended Abstracts, Electrochem. Soc., New Orleans, October 1984.

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AREA OF RESEARCH / DOMAINE DE RECHERCHE
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- ☐ Biotechnology / Biotechnologie
- ☐ Communications and Computers / Telecommunications et informatique
- ■ Energy / Énergie
- ☐ Environmental Science and Technology / Technologie de l'environnement
- ☐ Food-Agriculture / Alimentation-Agriculture
- ☐ Industrial Materials and Processes / Matériaux et procédés industriels
- ☐ Oceans / Océans
- ☐ Open / Ouvert

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Title of Project/Titre du projet: Photovoltaic Solar Cell

The advantages of growing compound semiconducting epitactic layers by metalorganic vapour phase epitaxy (MOVPE) are many: fine control of crystal deposition and impurity doping at relatively low temperatures in a single temperature zone using a cold-wall quartz reactor under vacuum conditions. Carrier concentration of undoped GaAs are in the $10^{15}cm^{-3}$ range, which is adequate for many applications except high resistivity epilayers. For instance a typical undoped n-type GaAs epilayer having a room temperature mobility of 6686 $cm^2V^{-1}S^{-1}$ contained donor and acceptor concentrations of $8.7 \times 10^{15}cm^{-3}$ and $3.7 \times 10^{15}cm^{-3}$ respectively. The corresponding mobility at liquid nitrogen temperatures was 23,770 $cm^2V^{-1}S^{-1}$. The dominant acceptor impurity was determined by low temperature photoluminescence to be zinc, which was subsequently found by the vendor to be present in the gallium source used in the MOVPE process - trimethyl gallium. Silicon is also present in this metalorganic but has not been positively identified in the GaAs epilayer. A repurification of the metalorganic is underway for high resistivity buffer layers. ZnSe has also been grown by MOVPE; the lattice mismatch with GaAs is small and it acts as a suitable antireflective coating. Surface morphology, although good, must be improved in order to decrease leakage current in the GaAs p-n junction. Under AM2 conditions an n^+np^+ GaAs cell having a 0.3μ junction and 2 cm^2 area gave 12% photovoltaic efficiency without an antireflective coating. With improved morphology, which is being addressed, efficiency in excess of 20% is expected.

Publications:

J. Phys. C : Solid State Phys., 15, 7043, 1982, "Metallic impurity donor band in compensated n-type GaAs".

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Can. J. Phys. accepted for special Technology issue, "Auto-epitaxie et proprietes d,As-Ga obtenu par MOVPE.

STRATEGIC FIELD: ENVIRONMENTAL TOXICOLOGY

DOMAINE THÉMATIQUE: TOXICOLOGIE DE L'ENVIRONNEMENT

Natural Sciences and Engineering Research Council of Canada
Conseil de recherches en sciences naturelles et en génie du Canada

ENVIRONMENTAL TOXICOLOGY

Environmental toxicology, for the purposes of this program, refers to the science that deals with the adverse effects on living things of chemical and physical agents present in the environment. Some chemical or physical agents, either entering the environment through human activities or occurring naturally, can have serious consequences to human health and to the environment generally. The support of research to elucidate the mode of action and the impact of these agents on living organisms is of particular interest to this field of the strategic grants program. Grant applications proposing work on compounds which are suspected but not proven to be toxic should include a summary of the evidence which suggests that these agents are likely to be relevant to environmental toxicology.

The field of environmental toxicology incorporates the following components:

1. Chemical and physical form of the toxic agent(s) released to the environment and the medium into which it is released.

2. Transformation of the toxic agent(s) by abiotic and biotic processes during its transport from the point of release to the receptor.

3. Quantitative metabolism of the toxic agent(s) in transporting and receptor organisms; this permits calculations of accumulation in food chains and doses to receptors.

4. The effects of these doses on individuals, populations and communities of receptors.

5. The results of these effects on the ecosystem.

However, in any study of toxicology it is important that these components not be considered in isolation from each other. For example, the physical and chemical forms of released pollutants will determine their toxicity and environmental behaviour, especially their transformation and transport. The medium into which they are released will determine which of the candidate receptors will be most affected and the most probable routes of intake.

The understanding of the mechanisms of action and the relationships between the agents and the environment requires input from a variety of disciplines such as chemistry, biology, physiology, genetics and related areas; therefore, research of a collaborative, multidisciplinary nature is encouraged.

Monitoring per se of levels of chemicals or biological systems in media or receptors is not eligible for support under this program, nor is the routine assessment of large numbers of chemicals.

LA TOXICOLOGIE DE L'ENVIRONNEMENT

La toxicologie de l'environnement, dans le cadre de ce programme, est la science qui traite des effets nuisibles que les agents physiques et chimiques présents dans l'environnement ont sur les organismes vivants. Certains de ces agents, présents dans l'environnement de façon naturelle ou à cause de l'intervention humaine, peuvent avoir des conséquences sérieuses sur la santé et sur l'environnement en général. L'aide à la recherche visant à élucider les mécanismes d'action et l'impact de ces agents sur les organismes vivants est une importante facette du programme de subventions thématiques en ce domaine. Les demandes de subventions de recherche traitant de produits qu'on soupçonne d'être toxiques sans en détenir la preuve devraient faire état des raisons qui font qu'on peut considérer ces produits comme relevant de la toxicologie de l'environnement.

Ce domaine comporte cinq secteurs principaux.

1. Nature chimique et physique des agents toxiques et du milieu dans lequel ils sont émis.

2. Transformation des agents toxiques par des processus biologiques et non biologiques entre leur point de déversement et leur milieu récepteur.

3. Métabolisme quantitatif des agents toxiques dans les organismes porteurs et récepteurs; on peut ainsi calculer leur concentration dans les chaînes alimentaires et dans les doses absorbées par les hôtes (récepteurs).

4. Effets de ces doses sur des sujets isolés, sur des populations et sur des communautés d'hôtes.

5. Conséquences de ces effets sur l'écosystème.

Cependant, dans toute étude toxicologique, il est important que ces composantes ne soient pas étudiées de façon isolée. Par exemple, la nature physique et chimique des polluants émis a une incidence sur leur toxicité et leur évolution dans le milieu et, en particulier, sur leur transformation et leur transport. C'est le milieu dans lequel ils sont émis qui déterminera quels hôtes potentiels seront les plus affectés et quelles seront les voies probables d'absorption.

La compréhension des mécanismes d'action et de l'interaction des agents et de l'environnement exige l'apport de plusieurs disciplines comme la chimie, la biologie, la physiologie, la génétique et d'autres domaines connexes; par conséquent, on encourage la recherche collective multidisciplinaire.

La simple surveillance des niveaux des produits chimiques ou des systèmes biologiques dans les milieux et les hôtes n'est pas admissible à ce programme, pas plus que l'examen routinier de nombreux composés chimiques.

Some areas of special interest and opportunity for research are the following:

a) Investigations of structure/activity relationships, speciation and of alterations of the toxic substance in the environment, and resulting alterations or enhancements of toxicity.

b) Quantitative study of the kinetics of toxic substances in living organisms and/or in the ecosystem.

c) Development of improved analytical methods, provided such work is integrated with research in toxicology and applied to biological systems.

d) Quantitative studies of the relationships between doses and various toxic responses of organisms, especially as related to:

- long-term, low-level exposure;
- interactions of toxic agents with other environmental variables such as temperature, acidity, specific nutrients, etc.;
- interactions of toxic substances with each other, including the effect of many simultaneous stresses;
- integrative effects such as those on reproduction, growth and behaviour.

e) Development and validation of predictive screening tests for toxic substances using lower organisms and cell and tissue culture approaches.

f) Assessment of the effects of chemical or biological environmental hazards.

g) Development of new methods for decreasing the effects of toxic substances in the environment including waste management.

Applicants are urged to familiarize themselves with Good Laboratory Practice (GLP) and other appropriate protocols, such as the OECD guidelines for ecotoxicity testing and the protocols of the Toxic Substances Control Act (TOSCA).

February 1985

Voici des domaines de recherche d'un grand intérêt offrant des possibilités intéressantes:

a) Recherches sur les relations entre les activités et les structures, sur la spéciation et sur les changements de la substance toxique dans l'environnement, et sur les changements ou les augmentations de toxicité qui en découlent.

b) Études quantitatives de la cinétique des substances toxiques dans les organismes vivants et/ou dans l'écosystème.

c) Mise au point de meilleures méthodes analytiques, à condition que ce travail soit intégré à de la recherche en toxicologie et appliquée à des systèmes biologiques.

d) Études quantitatives des relations entre les doses absorbées et les diverses réactions toxiques des organismes, surtout en ce qui concerne:

- les effets à long terme des agents toxiques en faibles concentrations;
- les interactions d'agents toxiques et d'autres variables de l'environnement comme la température, l'acidité, certaines substances nutritives, etc.;
- les interactions de substances toxiques les unes avec les autres, y compris l'effet de plusieurs causes simultanées de stress;
- les effets globaux, comme les effets sur la reproduction, la croissance et le comportement.

e) Mise au point et validation de tests prédictifs de détection des substances toxiques, en ayant recours aux organismes inférieurs et à la culture des cellules et des tissus.

f) Évaluation des effets chimiques et biologiques néfastes pour l'environnement.

g) Mise au point de nouvelles méthodes visant à diminuer les effets des substances toxiques dans l'environnement, y compris la gestion des rebuts.

Les candidats doivent connaître les directives des "Bonnes pratiques de laboratoire" et autres protocoles pertinents comme les lignes directrices régissant l'analyse de l'écotoxicité de l'OCDE et les protocoles du "Toxic Substances Control Act" (TOSCA).

février 1985

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☐ Oceans / Oceans
■ Environmental Toxicology / Toxicologie de l'environnement
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Title of Project/Titre du projet: Influence of Aroclor® and Mirex on Male Reproductive Function in Captive Falcons

In a recent study, Bird et al. (1983) found that Aroclor 1254 and Mirex significantly reduced sperm concentrations and numbers of single male American kestrels (Falco sparverius) ejaculated by massage, but were unable to conclude that the PCB or Mirex reduces the male's capability to fertilize eggs because the artificial insemination techniques were unsatisfactory for this purpose. They were also unable to explain why these chemicals reduced sperm concentrations in the male kestrel. The ideal method to answer these questions would be to introduce males previously exposed to the pollutants to "clean" females just prior to the breeding season. Hence, a study was undertaken: 1) to dose single male kestrels with levels of Aroclor 1254 and Mirex similar to the previous study; 2) to introduce these males and appropriate controls to undosed captive females during breeding season; 3) to monitor reproductive performance of the pairs and evaluate reproductive hormone levels; and 4) to relate testicular histology and pollutant residues in selected tissues to the aforementioned.

In 1983, 40 male kestrels from the McGill University colony were evenly divided into 4 treatment groups: Control (placebo), Aroclor (33 ppm daily), Mirex (8 ppm daily) and Aroclor/Mirex (33 ppm and 8 ppm daily). Randomly allocated to breeding cages 1.2 X 2.4 X 2.4 m (LXWXH) with suitable perches and nestboxes, each male was fed daily 1 frozen-thawed day-old cockerel with 0.1 ml of the appropriate chemical dissolved in vegetable oil and injected into the breast muscle from March 23 to May 6. Control males' cockerels were injected with vegetable oil only.

On May 7, a female was introduced to each of the 40 males. From May 12 to August 19, 24 randomly selected pairs (6 per group) were sampled for 1.0 ml of blood weekly. The plasma was frozen for later testosterone analyses. Twelve birds (3 from each group) were randomly chosen from the remaining 16 and killed by cervical dislocation 5 days after its female laid its last egg of the season. A 1 ml blood sample was collected, carcasses were weighed, liver, brain and testes removed, weighed and frozen in liquid nitrogen (for later testicular histology), and the right testes and small piece of liver stored in formalin. Twelve more males (3 from each group) were killed 60 days after the laying of their females' last egg and the dissection procedure outlined above followed.

From May 9 to July 27, all available pairs were observed for signs of reproductive brhaviour, i.e. copulations, food transfers, and male nestbox entries. Four 10-min observation sessions for each pair were conducted weekly. The first 5 eggs were removed as laid, but eggs laid subsequently were left in the nestbox for the female to incubate. All eggs were candled for fertility and undeveloped eggs were examined macroscopically for signs of embryo growth.

In 1984, 4 groups of 9 birds were dosed from March 16 to May 3 and blood-sampled from April 5 to April 25. Twenty males were killed on May 3 and 4 and dissected as above. A female was assigned to each of the remaining 16 males. Each male was blood-sampled weekly until May 23 and each pair observed for 8 to 9 ten-minute sessions weekly from May 27 to May 28. The remaining males were killed between May 23 and June 12 and eff fertility was examined once more.

Although statistical analyses are not fully completed, the Control pairs laid eggs first in both years, while the Mirex pairs were the slowest to initiate egg-laying on average. In 1983 and 1984, the Control and Aroclor pairs copulated most frequently overall, while the Mirex group copulated the least number of times. In 1983 the Control males entered the nestboxes the most frequently and the Mirex males showed the least interest in them. Although the Aroclor/Mirex males had the highest entry rate in 1984, the Control males again showed more interest in the boxes than did Mirex males. Food transfers, a strong indicator of pair-bonding in kestrels, was most prevalent in the Controls and weakest in the Mirex males. Finally, the Mirex males were associated with the poorest fertility in both years.

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☐ Food Agriculture / Alimentation Agriculture
☐ Industrial Materials and Processes / Matériaux et procédés industriels
☐ Ocean / Océan
☐ Other / Autre

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Title of Project/Titre du projet Methylation of Lead and Tin in the Environment: Conversion of Inorganic Lead(II) and Tin Salts to Alkyllead(IV) and Tin(IV) by Microorganisms and Active Sediments.

Objectives: Elevated levels of inorganic lead, chiefly from anthropogenic sources are found in Canadian inland waterways (e.g. 11 x 10^3 ng/kg in Hamilton Harbour compared to 1-2 ng/kg in the deep ocean). Inorganic and organotins, the latter from industrial uses such as PVC stabilisers catalysts and biocides are also present in the Canadian environment. Of major recent concern has been the possibility that inorganic forms of lead and tin might be converted in the environment via microbiological or chemical mechanisms to more toxic organometallic species such as Me_3Pb^+, Me_4Pb and Me_3Sn^+. Prior to this grant only sporadic and conflicting reports of lead or tin methylation in the environment had appeared (see e.g. Nature, **259**, 158, 1976; Nature, **253**, 263, 1975; Nature, **291**, 228, 1981). The principal overall goal of the research project was as follows:

To attempt to answer the question "can lead and tin salts be methylated to toxic methylleads and tins in the environment?" To achieve this goal a number of objectives were set: (i) To examine the ability of various sediments from Ontario sources to methylate lead and tin salts via microbiological mechanisms: (ii) to evaluate the possibility of purely abiotic (chemical) means of transforming Pb(II) and Sn(II) to organometallic species: (iii) to develop sensitive analytical methods for the accurate determination of R_3Pb^+, R_2Pb^{2+}, Pb^{2+} and R_4Pb in environmental samples: (iv) to investigate the capabilities of various pure strains of microorganisms to methylate Pb(II) and Sn(II): (v) to attempt to grow metal resistant strains of bacteria which might be capable of increased methylation.

Results and Their Significance

1. Sensitive derivatisation coupled to GC/AA methods have been developed to analyse ng quantities of alkylleads and tins.
2. No consistent evidence has been found for lead(II) or tin(II) methylation by active sediments.
3. No pure strains of microorganisms were found which consistently methylate lead(II) or tin(II).
4. Chemical methylation (abiotic) of lead(II) to methyllead(IV) compounds by CH_3I is facile. Such a process may be environmentally important in view of the presence of methyliodide in natural waters.
5. Methylation of tin(II) by cell free extracts (from sediment) has been clearly demonstrated.
6. Strains of pseudomonas, resistant to 1000 ppm lead have been cultured.
7. Transmethylation to lead(II) from other organometals is not likely to be of environmental significance but alkylleads can methylate tin.

Publications and Reports: The methodology developed for this work has now been published (Anal. Chim. Acta. **146**, 211-217 (1983)). There have been numerous requests for information on the instrumental methods and protocol used. The work on chemical methylation of lead(II) has only recently been completed (fall'84) and a full paper entitled "Chemical Alkylation of Lead(II) Salts to Dimethyl, Trimethyl and Tetramethyllead(IV) in Aqueous Solution" is in preparation. The studies on cell free extracts are novel and a communication "Methylation of Tin(II) by Cell Free Extracts of Pseudomonas" for submission to Nature is in preliminary draft form. Detailed reports on results obtained are available from the authors.

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- ☐ Open / Ouvert

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Title of Project/Titre du projet: Effects of environmental sulfate on sulfate metabolism and calcium hyneostasis.

It is a common belief that acid rain is composed entirely of substances that are immediately toxic to animal and human life. However, one of its components, inorganic sulfate, is a compound that is a normal part of our chemical metabolism and is essential for proper growth. For several years now, we have been studying sulfate metabolism in animals and in humans, especially infants, children and pregnant mothers.

One can think of sulfate as a raw material that is chemically added to other much larger and more complex molecules of the body such as proteins, lipids and sugars, so as to modify or improve their function. Sulfate is specifically used in large quantities to manufacture connective tissue, the material that makes up the cartilage of joints and the tendons of muscle. It is also used in the metabolism of steroid hormones and it plays an important role in the way the body disposes of drugs and poisonous substances including those that cause cancer. To achieve all of this, the body must control its sulfate supply and maintain an inventory appropriate to its needs.

Our studies have already taught us one thing: environmental increases in sulfate supply are not harmless in the long run. They alter the body's handling of calcium--the essential mineral that makes up most of our bone substance and allows normal function of nerve and muscle cells. This is because sulfate binds calcium in the body, much the same way sulfate in acid rain is bound by the calcium in the lime used to neutralize contaminated lakes.

In this study, we have been attempting to answer several related questions about the biology of sulfate: how well can the body counteract the effects of increased sulfate on calcium? how much sulfate is too much? how does the body control sulfate so there is neither too much nor too little? how does the growing body (the fetus before birth and the infant after birth) assure a larger supply of sulfate to keep growing, then turn it off when growth finishes? The answers to these questions are important if we are to understand the long-term impact of an increased sulfur burden on our own human existence.

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FIELD OF RESEARCH / DOMAINE DE RECHERCHE
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Title of Project/Titre du projet: THE POTENTIATION OF VIRAL PATHOGENICITY BY ENVIRONMENTAL SURFACTANTS

This research had three objectives: 1. to determine what chemical structure or structures were present in the surfactant Toximul MP8 that caused increased mortality when combined with a virus infection; 2. to determine if the surfactant was present in detectable amounts in human autopsy tissue from children dying from Reye's Syndrome (RS) as well as children dying from other causes and 3. to analyse tissue from mice in order to correlate our experimental level of exposure to that of environment exposure.

Our results showed that the major non-ionic component of Toximul (dodecylbenzene sulfonate) and one of the anionic components tested were capable of significantly increasing the mortality if mice were pre-exposed to these chemicals and then infected with a human strain of influenza B. Analysis of the tissues for surfactant showed no significant difference between the control group and children with RS. However, specimens from people known to have died from a pesticide poisoning had increased values. Tissues taken from various anatomical segments of the nervous system in patients with RS suggested a pattern but numbers are too small yet to determine any definitive information from this.

This work is significant in that use of industrial surfactants such as Toximul MP8 constitute a huge industry in the United States and Canada and up to recently have been considered biologically inert. These studies support the fact that under certain conditions they can interact with other environmental substances such as viruses.

PUBLICATIONS

Renton KW, Crocker JFS, Digout SC, Lee SH, Rozee KR: Urea Cycle Enzyme Alteration and Viral Enhancement in Experimental Model of Reye's Syndrome. Presented at the 25th Canadian Federation of Biological Sciences, Edmonton, 1982.

Fung D, Safe S, Crocker JFS: Detection or Trace Levels of Polyethylene Glycol Ether Surfactants in Biological Tissues. Toxicological and Environmental Chemistry 8:109-118, 1984.

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Crocker JFS, Renton KW, Lee SHS, Rozee KR, Digout SC, McDonald ATJ: Biochemical and Morphological Characteristics of an Animal Model of Reye's Syndrome Induced by the Interaction of Influenza B Virus and a Chemical Emulsifier (Submitted to Lab. Invest.)

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- ☐ Open / Ouvert

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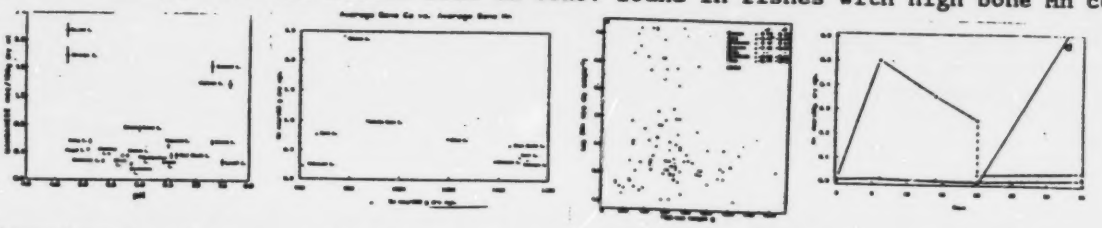
Title of Project/Titre du projet: The mechanism of action of manganese on fishes, in the context of manganese mobilization from soils and sediments in response to acid precipitation.

Component 1. Manganese concentration was determined by neutron activation analysis of lake sediments, 3-5 cores per lake, at 1 cm intervals, for 7 lakes. Shallow lakes showed little Mn retention, and deep lakes showed high retention (Fig. 1). One lake showed variability between sample sites differing in lake depth (Fig. 2). It may be possible to predict sediment Mn conc. from lake mean depth (Fig. 3). Sediments are being analyzed from 7 more lakes currently to test this model.

Component 2. Mn conc. was determined in lake water and correlated to lake $[H^+]$ ($r=0.89$). Two lakes contaminated by mine tailings were omitted from the regression (Fig. 4).

Component 3. The Mn conc. was measured (NAA) in the vertebral centra of 20 white suckers from each of 25 lakes (spanning a range of lake pH and Mn conc.). The results showed considerable variation between lakes, but with very little variation between fishes within lakes. The two most acid lakes showed very high conc. of Mn in bone. The while suckers from lakes Summit and Wallace, lakes contaminated with mine tailings, also showed high Mn conc. (Fig. 5). In S.M.R. 66% of the variance in bone Mn was explained by dissolved Mn; including DOC raised this to 86%. Bone calcium conc. also varied little between white suckers within lakes, but greatly between lakes, with the lowest bone Ca conc. found in fishes with high bone Mn conc. (Fig. 6).



Component 4. Mn conc. was determined in 3 soft tissues of white suckers, 20 fish from each of 7 lakes. White suckers from the most acid lakes, George and King showed significantly higher conc. of Mn in liver (Fig. 7) and kidney, but muscle was not significantly different.

Component 5. Mn uptake from water was determined for developing rainbow trout embryos and fry. Most of egg Mn content was lost at hatching as it was on or in the shell. Mn accumulation in fry post-hatching was significantly less in animals previously exposed to dissolved Mn (c) (Fig. 8) than controls (d).

Component 6. Mn uptake by adult rainbow trout from both food and water was measured in 130 fish. Mn conc. increased in bone (centra), liver, and gill tissue over 29 days at 5 ppm dissolved Mn. Mn uptake from water was greater than via food; only bone Mn increased in response to Mn-dosed food.

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☐ Open / Ouvert

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Title of Project/Titre du projet: INDUCTION OF GENETIC DAMAGE BY ENVIRONMENTAL MUTAGENS

In recent years it has become clear that the human population is exposed to many physical and chemical agents that are capable of causing cancer and a wide variety of genetic diseases. Not only ionizing radiation, but also sunlight and even heat can have deleterious genetic effects on cells. Chemicals capable of producing these effects are to be found in many industrial effluents, pesticides, herbicides, cosmetics, drugs and foodstuffs. Moreover, these various agents can sometimes interact with one another to produce effects that are even greater than would be expected on the basis of their independent effects. However, there is a great and important difference between discovering what might cause cancer and what actually does cause cancer. Indeed, it is possible that a large fraction of the cases of these diseases arise 'spontaneously' from biochemical causes in cells over which we have no control, and only a small fraction might come from avoidable exposure to environmental agents. Thus, it is essential to develop simple, rapid and inexpensive biological techniques that can be used to measure the extent to which the many different kinds of genetic changes in cells can be produced not only by physical and chemical mutagens, but also by biochemical disturbances in the normal processes whereby the genetic material is synthesized in cells. This project will address these questions. First, by the development of a sophisticated system, employing the yeast Saccharomyces cerevisiae, to measure the different types of genetic change in cells that could be involved in cancer. Second, to demonstrate the practical value of this system by using it to test the ability of various physical and chemical agents to produce genetic changes, both individually and in combination with one another. Third, to develop mathematical techniques whereby the relative efficiencies with which the various genetic (and presumably carcinogenic) changes produced by the agents tested can be compared and analysed. Fourth, to explore and analyse the recently discovered phenomena whereby induced disturbances in DNA nucleotide precursor pools give rise to mutation, mitotic recombination and other genetic effects known to be involved in the development of cancer. These disturbances can be produced by antifolate drugs which are widely used in cancer chemotherapy and which have been implicated as causal factors in the occurrence of additional primary tumours in cancer patients. These studies already have suggested that folate deficiency, which seems to be the only widespread vitamin deficiency among North Americans, may be a significant factor both in stimulating the genetic changes involved in cancer and in sensitizing cells to the carcinogenic effects of environmental mutagens.

The yeast testing system and the mathematical techniques developed will be made available to industry, government and other universities.

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- ☐ Oceans / Oceans
- ■ Environmental Toxicology / Toxicologie de l'environnement
- ☐ Open / Ouvert

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Title of Project/Titre du projet: Mode of action of third generation insecticides on reproduction and development: Prediction of developmental defects.

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Mode of action of third generation insecticides on reproduction and development: Prediction of developmental defects: Environmental Toxicology.

A new and novel approach to studying the normal functioning and development of animal embryos and tissues is the monitoring of small µA of electrical currents that exist around them. Electrical fields are important determinants or consequences of developmental events. Such currents either leave or enter living tissues in specific locations and provide a measurable physiological parameter by which to examine the effects of chemical compounds which could alter reproduction or embryogenesis adversely.

The vibrating probe technique developed by Jaffee and Nuccitelli provides an ultra-sensitive non destructive way to examine currents around living cells. A small (30 µM) platinum black sphere at the tip of a vibrating electrode detects the small electrical properties near the tissues with the aid of a lock-in-amplifier and chart recorder. Of the 23 laboratories world wide that have a vibrating probe facility, we have established the only one in Canada thus far.

To test if developing eggs have electrical currents and if they change when hormone analogues or 3rd generation insecticides are applied we have used the ovary of the insect Rhodnius as a model system. By careful analysis throughout an entire reproductive cycle we have shown a distinct pattern of electrical currents that exists around the developing eggs and that these change during oogenesis. By application of the insecticide juvenile hormone analogue Altosid or methoprene we have shown that during specific stages and in specific locations the currents are indeed affected. This is the first study of a hormone effect on the extracellular current pattern. Measurements on embryos are in progress. An insect growth regulator, fenoxycarb has been shown to block specific stages of embryo development.

Publications:

Huebner E. and W. Sigurdson. 1985, Ion current patterns in insect ovaries. Int. Soc. Dev. Biol. Proc. Aug. 1985.

Kelly, G.M. and E. Huebner. 1985, Rhodnius prolixus embryogenesis: Cellular events of normal development compared with those after juvenile hormone analogue perturbation. Int. Soc. Dev. Biol. Proc. Aug. 1985.

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FIELD OF RESEARCH / DOMAINE DE RECHERCHE
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☐ Biotechnology / Biotechnologie
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Title of Project/Titre du projet: The effects of pentachlorophenol on predator-prey behaviour using young largemouth bass (Micropterus salmoides) and the guppy (Poecilia reticulata) as a model system.

A study has been made into the toxic effects of continuous long term exposures to pentachlorophenol (PCP) on the early life stage of largemouth bass. Aspects studied were (1) 96 h LC50, (2) prey-predator interactions using guppies (Poecilia reticulata) as prey and young bass as predators, (3) ontogeny of feeding behaviour, and (4) growth in long and short term experiments.

(1) The 96 h LC50 of young bass up to 28 to 49 days of age was 280 ug/L; by 49 days of age it declined and fish tested thereafter up to 2 years of age had a 96 h LC50 of 136 to 190 ug/L. From an experiment in which fish were exposed continuously to various concentrations of PCP for their first 120 days, we estimated a 120 day LC50 of 54 ug/L.

(2) In a study of prey-predator behaviour for prey guppies exposed to PCP at 10, 50, and 70 % of their 96 h LC50 (1020 ug/L) it was found that, in a 4 week experiment, any changes in prey avoidance behaviour attributable to PCP was not detectable. However, by studying certain aspects of predator (juvenile bass) behaviour, one can determine the ease with which a prey is captured and correlate this with PCP exposure. We found that prey exposed to 50 and 70 % of their 96 h LC50 were significantly more easily captured than either the untreated controls or those exposed to 10% of the LC50; the latter two did not differ.

(3) The ontogeny of feeding behaviour for bass over their first 8 weeks of life was affected by concentrations of PCP above 45 ug/L after 4 weeks exposure.

(4) We also found that juvenile bass exposed continuously to different concentrations of PCP over the same first 8 weeks of life experienced a concentration-related reduction in growth at concentrations above 25 ug/L PCP. A short term experiment lasting 7 days following a 7 day acclimation period for individually housed 35 day old bass exposed to a range of PCP concentrations also resulted in a concentration-dependent reduction of food conversion efficiency at concentrations above 25 ug/L PCP. A second growth efficiency experiment involving high and low ration levels suggested that efficiency reduction (30%) is independent of ration level, and that PCP affects feeding motivation as well.

Overall, these studies show that exposure to PCP for bass in an early life stage affects both feeding behaviour and growth and that the 96 h LC50 declines between 28 and 49 days of age. Noticeable effects on feeding behaviour are not obvious until 4 to 5 weeks of age. Growth (measured as food conversion efficiency) is affected, declining on average by 30%, with a rapid onset within 7 days of the commencement of PCP exposure.

Since overwinter survival is size and energy (as stored lipid) dependent, these studies show the importance of not adversely affecting behavioural or physiological and biochemical processes, as can happen in the presence of some waterborne toxic chemicals like PCP.

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- ☐ Open / Ouvert

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Title of Project/Titre du projet: High Blood Pressure, Kidney and Coronary Heart Disease and Cadmium Ingestion in Canada: A Study of Receptors and Effectors

Cardiovascular (heart and blood vessel) disease is a leading cause of death in Canada and may be linked to trace metal contaminants in our food and drinking water. The amount of cadmium taken in by residents of Ontario, for example, exceeds that recognized as acceptable by the World Health Association. Over 20% of the Canadian people have the disorder of hypertension and it is essential that we know if there is an association between the disease and the environmental levels of cadmium. Cadmium accumulates in the human body over a period of time and there is reason to believe it may disrupt the operation of the cardiovascular system. The present investigation was an in vitro examination of the short and long term effects of exposure of isolated cardiovascular tissues to cadmium on nerve function and on blood vessel contraction capacity. It was found that cadmium can seriously depress the release of transmitter substance from the nerves to the heart. Additionally, the release of sympathetic transmitter to the blood vessels was impaired in parallel with a deterioration of the contractile performance. The actions of cadmium at the nerve level appear to involve a competition with calcium. Other studies established that cadmium inhibits the nerve membrane transport process which terminates the action of transmitter noradrenaline. Separately from the effect of cadmium on nerves, it was found that acute exposure to moderate or high concentration of cadmium directly depress blood vessel responses. Further work was done to examine the long-term effects of cadmium exposure on blood vessels. It was found that cadmium tended to depress blood vessel contractions following exposure of 18-24 hours, but that long term exposure for 96 hours (4 days) sensitized blood vessel responses to the sympathetic transmitter noradrenaline and to histamine. It appears cadmium, under certain conditions, can depress responses to blood vessels and, under others, can exaggerate or increase responses to blood vessels. These findings help explain the difficulties in establishing a clear pattern of effect of cadmium in the cardiovascular system. Long term exposure to cadmium, at concentrations not infrequently found in our drinking water supply, can, under certain experimental conditions, cause a sensitization of responses to the sympathetic nerve transmitter noradrenaline and other agents and these changes could be relevant to the high incendence of hypertension in Canada.

FIELD OF RESEARCH DOMAINE DE RECHERCHE
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■ Environmental Toxicology / Toxicologie de l'environnement
☐ Other / Autre

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Title of Project/Titre du projet: Chemical and Mutagenic Activity of Adsorbed Polycyclic Aromatic Hydrocarbons and Oxidation Products

Polycyclic aromatic hydrocarbons (PAHs) are produced by the combustion of all types of fossil fuels and by incineration of organic matter. These substances are associated with soot, fly ash and other particulate matter in the ambient atmosphere and are also present as contaminants in the water environment and soils. Many individual PAH compounds have been shown in animal tests to be potent carcinogens and mutagens. The prevailing theory to explain why some PAH compounds are carcinogens is based on the structural concept that carcinogenic PAHs contain a molecular "bay region" and this facilitates enzymatic conversion to a diol epoxide derivative, which is considered to be the ultimate carcinogen.[1,2]

However, we have found that non-bay region PAH structures are also mutagenic, whereas chrysene, which contains two bay regions, is not mutagenic and is inactive or only weakly active as a carcinogen. PAHs may undergo photochemical oxidation reactions in the environment, with production of phenols and quinones.[3] The most biologically reactive PAHs consist of 4 to 6 fused aromatic rings and are associated with and transported by airborne particulate matter. We have found that PAHs adsorbed on airborne particulate matter undergo photooxidation at a much slower rate in simulated sunlight than corresponding compounds in the free state. This indicates longer half-lives and more prolonged exposure to the toxic effects of PAHs on particles lodged in the lungs.

To study the effect of structure and electronic character on mutagenic activity of PAHs, a series of 4,5-bridged chrysenes was synthesized.[4,5] The 4,5-methanochrysene and the corresponding lactone were found to be mutagenic in accordance with the electron releasing nature of the substituents. However, the 4,5-oxobridged chrysene was found to be inert, consistent with the strong electron withdrawing nature of the oxo-group. Furthermore, benz(a)aceanthrylene was synthesized and found to exhibit mutagenic activity, although it does not possess either a "bay" or a "K" region.[6] The highly mutagenic and carcinogenic benzo(a)pyrene undergoes oxidations to a mixture of 1,6-; 3,6-; and 6,12-quinones which are direct-acting mutagens. However, the corresponding synthetic 4,5-BaP-quinone was found to be inactive.

Our results have provided new knowledge of the relationship between molecular structural — electronic properties of PAHs and their mutagenic activity. The information gained from this research should be useful to organizations and departments involved in health protection.

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1 Lehr, R.E. and Jerina, D.M. (1977) Arch. Toxicol. 39: 1-6.
2 Chang, R.L. et al. (1983) Cancer Res. 43: 192
3 Katz, M. et al. (1979) In: Polynuclear Aromatic Hydrocarbons, Jones and Leber, eds. pp 171-190, Ann Arbor Science.
4 Lee-Ruff, E., H. Kruk and M. Katz (1984) J. Org. Chem. 49: 553.
5 Lee-Ruff, E., Hopkinson, A.C., Kazarians-Moghaddam, H., Gupta, B., and Katz, M. (1982) Can. J. Chem. 60: 154-159.
6 Lee-Ruff, E., Raj, A.S., Kruk, H. and Katz, M. Electronic Effects in the Mutagenesis of Some 4,5-Bridged Chrysenes, submitted for publication in Mutation Research.

Form 145 (1984)

☐ Biotechnology / Biotechnologie ☐ Communications and Computers / Telecommunications et informatique ☐ Energy / Energie ■ Environmental Toxicology / Toxicologie de l'environnement
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Title of Project/Titre du projet: Heavy Metal Toxicity and the Cytoskeleton.

Traces of heavy metals have been released into the environment as a result of industrial and agricultural use of chemicals. Two of these metals, lead and mercury, are known to affect the nervous system adversely when low doses are absorbed over a long period. These effects are distinct from the results of acute poisoning, where these metals can damage many different biological processes, by generally inactivating proteins. At lower concentrations, the body has various defenses against heavy metals. If a component of the body has exceptional affinity for metal, gradual accumulation may occur until internal levels are sufficient for damage to become apparent. This appears to be the case for the nervous system and lead or mercury. The long term, low dose toxicology of metals is difficult to investigate: a strategy involving short term, high dose administration to animals, common in drug testing, may mislead because of the lack of specificity of action under such conditions. This project has taken an alternate approach of investigating the susceptibility of an isolated biochemical system, in order to assess its role as a possible target for lead or mercury. The method has advantages because very specific and precise information can be obtained. In addition, the use of experimental animals can largely be avoided. The disadvantage is that we only have inspired guesswork to determine which biochemical systems to investigate.

In this project, I have examined the interaction of lead and mercury with microtubules and their structural protein, tubulin. Microtubules are part of the cytoskeleton and are major components of brain and nerves, and in nerves are involved in axoplasmic transport, the supply line between the nerve cell body and its synapse. Some additional evidence pointed to the microtubules as a possible target for heavy metal. Microtubules function in cell division, and it was known that mercury induces a state known as c-mitosis, also characteritic of cells treated with colchicine, a drug which binds directly to tubulin. Microtubules are fibres, 25 nanometer in diameter, made up of strands of tubulin protein subunits. In the test tube, purified tubulin can be made to reassemble into microtubules. My studies now demonstrate that low concentrations of lead or mercury inhibit microtubule assembly. One mercuric ion per tubulin abolished its ability to reassemble. Observation of an effect in a test tube can tell us that microtubules are a possible target of lead or mercury, but does not show that they are the target in a whole organism.where many other susceptible systems may be present. Many biochemical compounds bind lead or mercury: the ultimate target is the molecule which binds the metal most tightly. The inhibition by lead was readily reversed by the presence of nucleoside polyphosphates, which are universally present in cells. Thus lead is not likely to inhibit microtubules in a normal cell environment. A different result was found for mercury. Many enzymes are inhibited by mercuric ion, but in almost all cases, the chelating agents EDTA or EGTA protect enzymes against the metal. Tubulin, on the other hand, was able to remove mercuric ion from EGTA, indicating that tubulin has an exceptionally high affinity for mercuric ion. Tubulin also bound the derivative methyl mercury, which for the complete organism is even more hazardous than mercuric ion since it can bypass many of the body's defenses against heavy metals. The inhibition of microtubules required about five-fold more methylmercury than mercuric ion, but still occurred at relatively low concentration. The natural sulfhydryl compounds glutathione and cysteine partly overcame methylmercury inhibition, and may function as the body's defense against methylmercury.

If microtubules and tubulin are the targets for mercury, we must account for the difference between methylmercury, more toxic to the whole organism, and mercuric ion which is more inhibitory to microtubules. My working hypothesis assumes that methylemercury is more readily distributed around the body, and can thus reach susceptible targets such as the nervous system, while mercuric ion is effectively screened out by the kidneys. Once within a nerve cell, demethylation may occur: the affinity of tubulin for the mercuric ion thus released would be so great that even if demethylation is a relatively minor process, eventually sufficient mercuric ion would accumulate to disable the microtubule system. Further work is needed to determine whether the mechanism suggested in this hypothesis can in fact operate.

FIELD OF RESEARCH / DOMAINE DE RECHERCHE
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■ Environmental Toxicology / Toxicologie de l'environnement
☐ Open / Ouvert

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Title of Project/Titre du projet:

Aluminum-organic speciation and acute toxicity to fish

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Aluminum is a very abundant element on the crust of the earth. It is generally non-reactive, being retained in the solid mineral phase. When the acidity of aquatic systems increases below a pH of about 5, aluminum is mobilized and can be toxic under certain conditions.

This research considers the acute toxicity of aluminum at a pH of 5 to common shinner minnows (Notropis Cornutus) in a synthetic dilute water similar in composition to waters found on the Precambrian Shield. Specifically, the lethal dose of aluminum was defined for short term experiments (1-50 hrs) as influenced by weak aluminum complexes (fluoride) and stronger organic complexes (malic and citric acids). In addition, histological examination of gills of fish was carried out, both in simple inorganic solutions and in solutions containing aluminum complexing substances.

A lethal dose for 50 percent mortality of aluminum of 40-50 µg/L is found for simple inorganic systems. On the other hand, there is complete survival at 270 µg/L aluminum when a strong complex, citric acid, is added even at complex:aluminum molar 1:6. Weaker complexing agents show intermediate results; malic acid suppresses all toxicity at 270 µg/L when the malate:aluminum ratio is 2:1 or greater. Fluoride suppresses all toxicity when the fluoride: aluminum mol ratio is 6:1 or greater. Intermediate suppression is shown with intermediate ratios of compled to aluminum ratios.

Histological examination of the gill shows that the double epithelial layer is completely sloughed off from the underlying basal lamina at 150 µg/L aluminum without complex. Thus the pillar cell-blood channel system is completely exposed to external aluminum and low pH. This would certainly cause ionic homeostatic problems and result in suffocation due to negligible gas exchange. At lower aluminum levels of 40-120 µg/L, the secondary lamellae were less disrupted but appeared fused together causing congestion along the length and allowing only communication with the marginal blood channels; thus the surface area for gas exchange is drastically decreased. In addition, a thickening of the fill mucous layer was also evident in all aluminum stressed fish; however, when the epithelial layer was sloughed off at high aluminum concentrations, there was an absence of a mucous adhering layer with microvilli, resulting in an absence of a protective coating of mucous. None of these effects were observed in control fish at pH 5 or those with complexing agents added at levels of total lethal suppression.

Technical Reports:

Kramer, J.R., and J. Hummel (1985) Aluminum Toxicity .. Histological Examination and Suppression by Complexes. E.G.R. No. 1985/1, McMaster University, Department of Geology, Hamilton.

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■ Environmental Toxicology / Toxicologie de l'environnement
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Department/Departement: Environmental Toxicology Program, Department of Biological Sciences
University/Université: Simon Fraser University
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Title of Project/Titre du projet: Metabolic disposition and sublethal effects of chlorodiphenyl ethers in fish and rats

Chlorinated diphenyl ether (Cl-DPE) are ubiquitous in the environment, particularly the aquatic environment. However, the environmental toxicity of Cl-DPE has not been examined in detail. In our original submission, we proposed (a) to study the kinetics of accumulation, metabolism and clearance of Cl-DPE in fish and rats (b) to study some sub-lethal histopathological and biochemical effects of these compounds in fish and rats (c) to devise a toxicokinetic model of disposition of Cl-DPE in fish and rats. All these objectives have been achieved.

We studied the acute toxicity of Cl-DPE in mice (LD_{50}) and trout (LC_{50}) and demonstrated that Cl-DPE are very toxic to fish but relatively non-toxic to mice. We placed trout in flowing water containing 100 ppb of Cl-DPE and found that the fish took up the chemicals rapidly but eliminated them slowly. The rates of Cl-DPE elimination from trout were inversely proportional to the degree of chlorination of the molecules.

Cl-DPE are absorbed by rats via the skin and the gastrointestinal tract. The urinary metabolites of four representive Cl-DPE were isolated and characterized. Low chlorinated Cl-DPE were metabolized by rats mainly to hydroxy and methoxy derivatives. They were also metabolized to reactive metabolite(s) which bound with tissue proteins irreversibly. The toxicological consequence of reactive metabolite formation remains to be determined.

Individual Cl-DPE was administered to rats and trout (100 mg/kg, ip) and its effects on hepatic mixed-function oxidases (MFO) activities and ultrastructures were examined. No MFO activities and histological changes were observed in the hepatocytes of trout. In contrast, both MFO activities and smooth endoplasmic reticulum in hepatocytes increased among rats pretreated with some of these chemicals.

Following intravenous administration of a Cl-DPE to rats and skate, the metabolic disposition of Cl-DPE were described by a three compartment, open toxicokinetic model. However, a two compartment, open toxicokinetic model is best to describe the disposition of a Cl-DPE which is given to rats orally or dermally. With the aid of a computer, we can predict the body burdens of animals and fish which have been exposed chronically to Cl-DPE.

In summary, our results show that the metabolic disposition of Cl-DPE in animals are very similar to those of PCB. The main difference is that Cl-DPE are more easily degraded and excreted than PCB.

Publications arising directly from this research include: (a) "Studies on the uptake, elimination, LD_{50}, LC_{50} of 4-chlorodiphenyl ether in trout, rats and mice", in Abstract Proceedings of the 24th Canadian Federation of Biological Societies (CFBS); (b) "Effects of chlorination on the uptake and clearance of chlorinated diphenyl ether (CDEs) in trout and skate", in Abstract Proceedings of the 25th CFBS; (c) "Studies on the metabolic disposition and irreversible binding of ^{14}C-diphenyl ether (^{14}C-DPE) in rats", in Abstract Proceedings of the 25th CFBC; (d) "Induction of hepatic mixed-function oxidases (MFOs) of rats by chlorinated diphenyl ethers (CDEs)", in Program and Abstract of the International Conference on Cancer in the Workplace, p. 97 (1983); (e) "Irreversible binding of ^{14}C-diphenyl ether-derived radioactivity to liver microsomes *in vitro* and tissue proteins *in vivo*", in Drug Chem. Toxicol. 6(3), 285-294(1983); (f) "Disposition and metabolism of diphenyl ether in rats", in Xenobiotica 13(10), 627-633(1983) (g) Chui, Y.C. Ph.D. thesis, Dalhousie University, 1983.

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Name/Nom: AT Matheson[1] (Principal Investigator), MJ Ashwood-Smith[2], GR Branton[3], JT Buckley[1], EE Ishiguro[1], WW Kay[1], A McAuley[3], JA McCarter[1], RH Mitchell[3], RW Olafson[1], TW Pearson[1], PR West[3], TJ Trust[1]
Department/Département: [1]Biochemistry and Microbiology, [2]Biology, [3]Chemistry
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Title of Project/Titre du projet: TOXICOLOGY IN MARINE AND AQUATIC SYSTEMS

The purpose of these studies was to investigate aspects of aquatic and marine toxicology arising from pollution with traces of metals and organic compounds as a result of industrial activity. (A) Effects of prolonged exposure of salmonids to sublethal levels of copper, zinc and cadmium was investigated when juvenile rainbow trout, coho salmon and chinook salmon are continuously exposed to zinc, copper and cadmium at sublethal concentration, similar to those found in water polluted by base metal mine tailings, the concentration of metallothionein is elevated in the liver. A procedure has been developed, for use in field exposures, whereby the metallothionein concentration can be used to determine "safe" limits of metals in aqueous environments. This procedure gives a measure of the metal that is biologically available hence it is not necessary to know the chemical speciation of the metal but only its total concentration. This makes possible the direct measurement of "safe" levels of zinc, copper and cadmium under actual environmental conditions without making assumptions inherent in calculations of safe levels based on measurement of lethality. (B) Effect of heavy metal contamination on the susceptibility of salmonids towards an infectious disease such as furunculosis has been investigated. The initial exposure of coho salmon to 70 ppb Cu^{+2} increased the susceptibility of the fish to furunculosis. However, fish which had been chronically exposed to Cu^{+2}, i.e., Cu-tolerant fish, were no more susceptible to disease than unexposed controls. These results suggest that stress induced by exposure to Cu^{+2} increased the susceptibility of fish to furunculosis, but the basis for this is still unknown. Cu-induced stress apparently did not affect the humoral immune response to surface antigens of the bacterium, Aeromonas salmonicida, which is the causative agent of furunculosis. The effect of Cu^{+2} on the fish cellular immune system is still under study. In an effort to develop a more realistic model for these studies, techniques were devised to experimentally prepare asymptomatic carriers of furunculosis. These carrier fish were stable for at least 6 months and furunculosis could be activated by inducing stress. Experimental vaccines which are effective in protecting fish from furunculosis have been developed. (C) Chemical transformation in aqueous systems of organic pollutants, such as methoxychlor, has been investigated. Clearance of methoxychlor after direct injection into Western Canadian rivers for black fly control is an environmental consideration. A comprehensive examination of methoxychlor chemistry has led to information transfer to agencies employing 25% EC methoxychlor in the field (impurities). Chemical model photodegradation studies on organochlorine compounds suggest that rapid clearance in neutral solution may occur when donar sensitizers or quinones are present with available reducing agents (H-donar). Dechlorination of methoxychlor occurs in air when the appropriate photoreducing system is available.

PUBLICATIONS:

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■ Environmental Toxicology / Toxicologie de l'environnement
☐ Open / Ouvert

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Title of Project/Titre du projet: "ENVIRONMENTAL TOXICITY OF NITRO POLYCYCLIC AROMATIC HYDROCARBONS"

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Simple summary for NSERC

Nitro derivatives of polycyclic aromatic compounds (nitro PAH's) are found in many combustion products and, in addition, can be formed in the environment through the reaction of NO_x with polycyclic hydrocarbons in the presence of traces of acid.

Nitro PAH do not directly damage DNA; rather bacterial and animal cells metabolize these agents to reactive compounds which do react with DNA. We have, therefore, studied metabolism of the extremely potent bacterial mutagens, 1,6- and 1,8-dinitropyrene (DNP) in detail to determine the chemical identity of the ultimate mutagen and the identity of the adducts formed when these compounds react with DNA. These studies have shown that the DNA adduct found is formed by the addition of activated DNP to the C_8 position of guanines in DNA. The reactive metabolite is an acetylated derivative of 1-hydroxylamino-8-nitropyrene - probably the O-acetyl but this remains to be proven. The nitroreductase and acetyl transferase enzymes which catalyse the reactions involved have been partially characterized.

In contrast to the nitropyrenes which are direct acting and induce mutations in bacteria in the absence of exogenous activating systems, there are other nitro PAHs that are mutagenic to bacteria only in the presence of enzyme preparations (called S9 fraction) from rat liver. We have studied the activation of one of these compounds, 3-nitroperylene, in detail and shown that the tissue level of the mixed function oxidases involved is markedly influenced by other chemicals and that these enzymes can be induced by pre-treating rats with either 3-methylcholanthrene or phenobarbital. A number of uncharacterized, oxidized 3-nitroperylene metabolites are formed. One or more of these are then taken up by the bacteria and undergo nitroreduction and acetylation to yield the ultimate mutagen.

In the course of this work over 2 dozen new nitro PAHs and their derivatives and analogues have been synthesized and characterized spectroscopically. Improved techniques have been devised for the detection and quantitation of nitro PAH's in environmental samples. Air particulates collected in the Hamilton and Toronto region contained 40-180 pg/m^3 air of 9-nitroanthracene and 1-nitroperene. Diesel exhaust samples contained several nitro PAH's in the 1-200 ppm range.

FIELD OF RESEARCH / DOMAINE DE RECHERCHE
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■ Environmental Toxicology / Toxicologie de l'environnement
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Title of Project/Titre du projet: Physical toxicity and the effects of halogenated hydrocarbons on mammalian cells.

Many of the biological effects of persistent hydrocarbons pollutants are due to a general mechanism of toxicity, physical toxicity, which is dependent on the size of the molecule. We can use molar volume correlations to dissect the toxic effects of these molecules into a component due to physical toxicity and a component, where one exists, due to specific chemical toxicity. The toxicity of purified PCB and PBB isomers tc mammalian white blood cells, and the effects of these pollutants on cell enzymes was determined. A new correlation was discovered between the size of the pollutants and the toxicity of the compound. This correlation enables the prediction of the toxicities of new compounds, it enables us to estimate the concentration of the compound in the cell membrane where it is active. In the membrane of the cell, the halogenated hydrocarbons cause inhibition of membrane enzyme activities. We have also shown that these compounds will inhibit soluble protein enzymes, in a similar manner to that in which they act on cell membrane enzymes. The compounds will inactivate these enzymes even when the compound is too insoluble to dissolve in the water phase of the enzyme solution. Thus the toxicity is being expressed as a surface effect, and the lack of solubility of a pollutant does not guarantee that the pollutant will be harmless to living things. The correlations that we have described can be used to predict the safe levels for chemicals in water or air, and can be used to design less toxic solvents for industrial and home use. For example, we can predict which solvents can be abused by "glue-sniffers" and which solvent replacements could be used to render glues and other household products non-narcotic. The correlations can be and have been used to design anesthetics for inhalation. The following publications have resulted from this study:-

F.J. Sharom and A. Mellors 1980.
Effects of polychlorinated biphenyls on biological membranes: physical toxicity and molar volume relationships. Biochem. Pharmacol. 29, 3311-3317.

A. Mellors, J.C. McGowan and P. Ahmad 1982.
In The use of molar volumes in steroid structure-activity correlations. H.J. Lee and T.J. Fitzgerald 1982. Progress in Research and Clinical Applications of Corticosteroids. eds. Heydon and Son Inc. Philadelphia.

M.C. Sadler, F.J. Sharom and A. Mellors 1984.
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Physical aspects of the inhibition of enzymes by hydrocarbons: The inhibition of α-chymotrypsin by chlorinated aromatics and alkanes. Environ. Res. (1985) In press.

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A. Mellors and J.C. McGowan.
The uses of molecular volumes in biochemical pharmacology. Biochem. Pharmac. (1985) In press. J.C. McGowan and A. Mellors. Molecular Volumes in Chemistry and Biology. A monograph to be published by Ellis Horwood, Chichester.

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☐ Oceans / Oceans
■ Environmental Toxicology / Toxicologie de l'environnement
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Title of Project/Titre du projet: Effect of heavy metals on the translation of genetic information in mammalian tissues.

The objectives were to study the effects of Pb, a ubiquitous environment pollutant, in mammals. The means were to look at enzymatic activity and protein synthesis in target tissues such as brain and kidney where cytological changes occur after certain levels of Pb exposure. Our results from controlled laboratory experiments in rats show that tissue effects are not well correlated with tissue Pb or blood Pb levels. Furthermore, the Pb effects on kidney enzymes and on brain protein synthesis are quite marked at tissue concentrations which, when effected by simply adding Pb in vitro to the enzyme experiment, do not occur. In other words, the lead effects on gene expression which we detect are only evoked in the whole animal, not in vitro.

In infant rat brains, chronic or acute Pb induced decreases of messenger RNA (mRNA) and of the protein synthesizing enzymes known as aminoacyl-tRNA synthetases. In young adult rats, Pb induced increases in both the mRNA for urokinase, the kidney plasminogen activator, and also in the activity of this enzyme, and is possibly implicated in kidney tumour development. In both acute and chronic Pb exposure, similar decreases in the activity of 2 important transport enzymes occurred in the kidney brush border, in spite of widely different tissue Pb levels. Another result was the response to Pb in the liver, which was similar to that resulting from another toxic chemical, methylmercury, and the observed release of serum acid glycoprotein could be a useful indicator of toxic effects.

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(Check one/cocher la case appropriee)

☐ Biotechnology / Biotechnologie	☐ Communications and Computers / Telecommunications et informatique	☐ Energy / Energie	☒ Environmental Toxicology / Toxicologie de l'environnement
☐ Food-Agriculture / Alimentation-Agriculture	☐ Industrial Materials and Processes / Materiaux et procedes industriels	☐ Oceans / Oceans	☐ Open / Ouvert

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Title of Project/Titre du projet: Soil processes as early indicators of terrestrial ecosystem stress.

Efficient monitoring of ecosystem degradation (resulting from industrial activities) or recovery (resulting from land reclamation) is essential to the development of appropriate industrial practices and proper land use planning by industrial and government groups. Ecological parameters such as species diversity and richness, plant productivity and food web complexity can be calculated from expensive, time-consumptive measurements, but such measurements frequently allow only "post mortem" analyses on areas exposed to stress. The basic hypothesis tested in this study was that ecosystem process measurements (carbon flux, nutrient cycling etc.) could provide rapid early warning of stress in terrestrial ecosystems caused by input of toxic materials. In this study the effects of input of S compounds to forest systems were investigated.

Studies were made at three ecologically analogous sites in pine forests (P. contorta x P. banksiana) located at increasing distances (2.8, 6.0 and 9.6 km) from a sour gas plant which had been emitting low levels of SO_2 for 20 years. Field studies showed that leaf litter decomposition and litter turnover rates were significantly slower at the site nearest the gas plant. Microbial biomass and basal respiration rate in the organic and mineral soil was significantly lower at the most impacted site. The study also indicated the need for a careful survey of mycorrhizal associations of both tree and shrub species.

Laboratory studies on the rates of mineralization of a variety of carbon and nitrogen substrates (glucose, cellulose, vanillin, casein, urea) indicated in all cases an initial inhibition of substrate decomposition and a longer time to achieve maximum CO_2 output in soil samples from the most impacted sites. Similarly ectomycorrhizal infection rates and nutrient release rates were significantly different in the most impacted soils as compared with control soils.

From these studies it was concluded that the use of total microbial biomass measurements, basal respiration rates under controlled conditions and reaction of soils to added carbon substrates (in this case vanillin) provide powerful monitoring methods which should be incorporated into biomonitoring systems.

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☐ Communications and Computers / Telecommunications et informatique
☐ Industrial Materials and Processes / Materiaux et procedes industriels
☐ Energy / Énergie
☐ Oceans / Oceans
■ Environmental Toxicology / Toxicologie de l'environnement
☐ Open / Ouvert

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University/Université: Université de Montréal
Phone number (optional)/N° de telephone (facultatif) (514) 343-6300
Title of Project/Titre du projet: Potentiation of Haloalkane Hepatotoxicity by Ketones

Ketones and ketogenic chemicals are widely used in the chemical industry. These chemicals have been shown to result in a biological interaction with a number of haloalkane solvents, also used extensively. This type of interaction is of particular interest in the industrial environment. However, these chemical combinations also occur as pollutants of other environments. The biological interaction results in a potentiation of the liver toxicity produced by a number of haloalkanes. Thus, normally nontoxic exposures to such haloalkane solvents become toxic when administered to subjects who have been previously exposed to nontoxic amounts of ketones or ketogenic chemicals. In this project, experiments were performed to assess the toxicological aftermath of the potentiations. The injured organ (liver) is regenerated within a few days after the interaction; furthermore, the regenerated organ is not more susceptible to a subsequent challenge to the haloalkane. Experiments were also performed to determine if repetitive exposures alter the toxic profile observed during acute exposure conditions. The finding is that, under repetitive exposure to a ketone, the toxic profile is not altered. Experiments were performed to answer the following question: are the exposure conditions in the laboratory setting relevant to those found in the industrial or environmental situations? To effect this comparison, different routes of exposure (oral versus inhalation) and varying exposure conditions (subthreshold, minimally effective and maximally effective) were used. It was found that the potentiation of CCl_4-induced hepatotoxicity can be predicted on the basis of the blood concentration of the ketone administered orally or by inhalation, provided one uses the appropriate exposure conditions based on the MED.

Charbonneau, M., Iijima, M., Côté, M.G. and Plaa, G.L. Evolution of rat liver injury in ketone-induced potentiation of CCl_4 toxicity. The Pharmacologist, 24: 171, 1982 (abstract)

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Kobusch, A.-B., Plaa, G.L. and du Souich, P. Effect of acetone, methyl-n-butyl ketone and streptozotocin-induced diabetes on the hepatic mixed function oxidase system Toxicologist 5: (abstract) (in press).

Caillé, G., Plaa, G.L. and Vézina, M. Toxic interactions between water pollutants. $CHCl_3$ interaction with the organochlorine pesticides Kepone and Mirex. I- Gas chromatographic determination of Kepone and Mirex in biological samples. Fund. App. Toxicol. (submitted for publication).

Kobusch, A.-B., Plaa, G.L. and du Souich, P. Effect of methyl-n- butyl ketone, acetone and streptozotocin-induced diabetes on the hepatic mixed function oxidase system. Toxicol. App. Pharmacol. (submitted for publication).

FIELD OF RESEARCH / DOMAINE DE RECHERCHE
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- ☐ Communications and Computers / Telecommunications et informatique
- ☐ Industrial Materials and Processes / Materiaux et procedes industriels
- ☐ Energy / Energie
- ☐ Oceans / Oceans
- ■ Environmental Toxicology / Toxicologie de l'environnement
- ☐ Open / Ouvert

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Title of Project/Titre du projet: Caractérisation du mode d'action des cancérigènes pancréatiques : réparation de l'ADN et activité poly(ADP-ribose) polymérase.

Nous avons au cours des deux dernières années developpé la technologie permettant de doser des quantités picomolaires de polymère dans des cellules en culture. De plus, nous avons démontré en collaboration avec le Prof. Peter Cerutti que les esters de phorbol pouvaient stimuler de façon appréciable les niveaux intracellulaires de polymère (1,2). Nous avons également developpé des anticorps polyclonaux monoclonaux contre la poly(ADP-ribose) polymérase ce qui a permis d'analyser sa distribution au cours du cycle cellulaire. Nous avons également démontré qu'il existait une corrélation directe entre le nombre de coupures dans l'ADN de SV40 et la stimulation de la poly(ADP-ribose) polymérase (3). Finalement nous avons démontré que la relaxation (4) de la chromatine causée par la poly(ADP-ribose) polymérase était réversible lorsqu'on traitait les nucléosomes relaxés avec de la poly(ADP-ribose) glycohydrolase (5). Nous pouvons maintenant isoler en grandes quantités de la poly(ADP-ribose) polymérase ainsi que du polymère purifié.

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FIELD OF RESEARCH / DOMAINE DE RECHERCHE
(Check one/cocher la case appropriée)

☐ Biotechnology / Biotechnologie
☐ Food Agriculture / Alimentation-Agriculture
☐ Communications and Computers / Technologies des communications et informatique
☐ Industrial Materials and Processes / Matériaux et procédés industriels
☐ Energy / Énergie
☐ Oceans / Océans
■ Environmental Toxicology / Toxicologie de l'environnement
☐ Other / Autre

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Title of Project/Titre du projet: Toxic and Metabolic Effects of Crude and Treated Oils on Birds, Particularly Seabirds

The project was stimulated by realization that major hydrocarbon developments will likely occur in Canadian coastal and continental shelf waters throughout the next several decades, and seabirds, by virtue of their habitat and very low reproductive capacities, may be at special risk from oil spills. Many of the bird colonies off Canada's East Coast are recognized as national and international assets and much concern has also been expressed about the possible effects to seabird life of oil development in the Arctic. Unlike (potential) impacts on fish and invertebrates which have been more extensively studied, the database on birds with respect to oil pollution is much more limited. This is especially the case for sublethal and embryological effects which formed the principal focus of this study. Much of the information that has been obtained is of immediate relevance for agencies in industry and government involved in environmental impact assessments. Research highlights in this regard include the following:

1) Complex petroleum mixtures can act in an antimutagenic manner reducing the overall toxicity potential of any mutagens which may be present in petroleum. This is an important perspective which should be included when evaluating the significance of petroleum as a source of mutagens in the aquatic environment.

2) Both juvenile and adult birds are indicated to have a high capacity for petroleum hydrocarbon metabolism, and can probably ingest substantial concentrations of petroleum via food or water without harm. The low concentration of petroleum found in the water column around exploratory or production well sites should present little problems for birds.

3) The coating of eggs with very low concentrations of either high (e.g. Hibernia) or low (e.g. Prudhoe Bay) paraffin crudes can result in marked embryo toxicity. Hydrocarbon vapors were also shown to be particularly toxic to bird embryos and, in the event of a major oil spill near a rookery, petroleum vapors more so than any other hydrocarbons, may pose the most significant toxicity threat. The noted special risk to embryos, from atmospheric vapors as well as egg coating, is especially useful information to consider when developing policy options for tanker routings or terminals near bird nesting sites.

4) Mixed-function oxygenase enzymes were markedly increased in a variety of life stages exposed to petroleum indicating the potential for use of these enzyme systems in monitoring studies. Their indicated value would be in "assurance" monitoring around oil development sites.

In addition to the above, which can be more or less viewed as knowledge of immediate utility, the research has provided insight of a more fundamental nature on mechanisms of hydrocarbon toxicity and such information can be more generally applied to other species including man. In this regard, we would like to highlight findings on the importance of metabolism in mediating toxicity and the tumor promoting characteristics of petroleum complexes. Further studies should determine if the enzyme DT-diaphorase plays a special role in hydrocarbon toxicity in seabirds as well as in other species.

FIELD OF RESEARCH / DOMAINE DE RECHERCHE
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- ☐ Biotechnology / Biotechnologie
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- ☐ Energy / Energie
- ☐ Oceans / Oceans
- ■ Environmental Toxicology / Toxicologie de l'environnement
- ☐ Open / Ouvert

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Title of Project/Titre du projet: Genotoxic effect of concurrent exposures of mammalian cells to particulates (asbestos and coal dust) and carcinogenic N-nitroso compounds

Human populations are constantly exposed to a multiplicity of environmental agents, the interaction of which can have a profound effect on cancer risk. One of the most well documented of such interactions involves combinations of asbestos and other environmental carcinogens. Epidemiological studies have shown that asbestos miners who smoke are at a greatly enhanced risk for lung cancer as compared with their non-smoking contemporaries.

The purpose of this study was to establish a model system which would simulate in vitro the exposure of human population groups to complex mixtures of carcinogens, both in the workplace and as a result of various lifestyle practices. Two common groups of carcinogens were focused on: asbestos and N-nitrosamines, as exemplified by the direct-acting nitrosamine N-methyl-N-nitrosourea (MNU) and dimethylnitrosamine (DMN), a nitrosamine requiring S9 activation. The interaction of these carcinogens was determined from the extent and type of clastogenic damage in mammalian tissue cultures.

All four of the examined asbestos fibers induced chromosomal aberrations, albeit to different degrees. Short chrysotile, intermediate chrysotile and crocidolite displayed similar activities, whereas amosite induced very few aberrations at doses as high as 100-200 µg/ml. The type of chromosome aberration induced by the fibers was predominantly partial or total fragmentation of single chromosomes with, in some instances, a "pulverization" of the entire chromosome complement.

Asbestos fibers and MNU were mixed together and immediately added to Chinese hamster ovary (CHO) tissue cultures. The percentage of metaphases displaying either chromosomal breakage or exchanges in cultures exposed to a combination of short chrysotile asbestos and MNU was roughly additive. Combinations of asbestos fibers with DMN in the presence of liver S9 mix resulted in a similar additive response. These results are in contrast to the synergistic (enhancing) effect of the concurrent exposure of cells to cigarette smoke and arsenic, cigarette smoke and chromium, or cigarette smoke and formaldehyde.

The results of the in vitro studies are currently being extended to in vivo situations by examining chromosomal fragmentation (micronucleus production) in bronchial cells obtained from lung lavages of smoking and non-smoking asbestos workers. It is hoped that this approach can be used to quantify genotoxic damage induced not only by asbestos alone but to study the effect of concurrent exposure to other carcinogenic mixtures and to identify individuals at elevated risk for bronchogenic cancer before any clinical symptoms are detectable.

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- ☐ Food-Agriculture / Alimentation-Agriculture
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- ☐ Energy / Energie
- ☐ Oceans / Oceans
- ■ Environmental Toxicology / Toxicologie de l'environnement
- ☐ Open / Ouvert

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Title of Project/Titre du projet:
Toxic Products of Polycyclic Aromatic Hydrocarbons in the Soil: Synthesis and Fungal Metabolism Studies

Polycyclic aromatic hydrocarbons (PAHs) and aza-PAHs are ubiquitous, increasingly detected environmental pollutants formed mainly from man-made sources. Since the accumulation rates of these substances are constantly rising, they will constitute a global environmental problem in the foreseeable future and their detection, identification, monitoring, toxicity, and fate in the terrestrial and aqueous ecosystems must be placed under continuous surveillance.

Canada is no exception to this analysis. In our highly industrialized nation, PAHs and aza-PAHs arise from the combustion of petroleum and coal products in both commercial and private sectors, from refuse incineration, and a multitude of other sources. Since a large proportion of these toxic substances are deposited in the soil it is obligatory to know their metabolic fate. The significance of this knowledge on soil quality for the vast agricultural areas in Canada and its implications for food quality are obvious.

Our studies are aimed at providing a comprehensive picture of PAH and aza-PAH metabolism by soil microorganisms. A large number of PAHs, aza-PAHs, and peri-methyl-PAHs were prepared by efficient and economic syntheses based on the aromatic directed ortho metalation strategy. These and other commercially available oxa-, thia- and aza-PAHs were subjected to metabolic screens using a variety of grown cultures of soil fungi. Emphasis was placed on Cunninghamellia elegans which had been shown to metabolize PAHs by other workers. Results of our incubation experiments indicate ring hydroxylation, sulfur atom oxidation, and methyl group hydroxylation with several microorganisms, in particular C. elegans.

This research has provided the first comprehensive results on PAH metabolism by soil microorganisms. We are endeavoring to extend this study in view of the importance of the data for environmental quality. This work also provided the incentive to establish CIDtech Research Inc., a wholly Canadian Corporation formed to sell PAHs to world-wide markets.

PUBLICATIONS

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FIELD OF RESEARCH / DOMAINE DE RECHERCHE
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☐ Communications and Computers / Telecommunications et informatique
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☐ Energy / Energie
☐ Oceans / Oceans
■ Environmental Toxicology / Toxicologie de l'environnement
☐ Open / Ouvert

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Title of Project/Titre du projet:
Methods for evaluating the effects of pesticides in the aquatic ecosystem.

Summary

A technique for evaluation of the effects of pesticides in the aquatic environment has been developed using model compounds such as permethrin, methoxychlor atrazine, fenvalerate and diuron. This technique has made use of enclosures, or limnocorrals, as a means of isolating sections of a body of water into separate, replicable compartments which may be treated with pesticides with minimal hazard to the larger water system. The technique has demonstrated replication, both within and between seasons, the ability to observe toxicity or lack of it to a large number of organisms at one time, as well as the impact of the pesticide on the ecosystem and the recovery of the organisms in the system. The technique has also been able to demonstrate changes in diversity as a result of selectivity of pesticide action, interactions caused by pesticide selectivity, the ability of the system to compensate for changes caused by the pesticide. Many of these phenomena would not have been observed in simple laboratory systems and complex laboratory systems to allow similar studies would have been much more costly.

The potential long term benefits to society and the environment of having a screening system for the impact of pesticides in aquatic systems are obvious.

Publications

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☐ Biotechnology
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☐ Communications and computer
Télécommunications et informatique
☐ Industrial Materials and Processes
Matériaux et procédés industriels
☐ Energy
Énergie
☐ Ocean
Océan
■ Environmental Toxicology
Toxicologie de l'environnement
☐ Other
Autre

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Title of Project/Titre du projet
Benthic plant communities in acid lakes, fluxes of aluminum and benthic faunal interactions.

Acidification of lakes has been shown to result in increased levels of aluminum, which is now at toxic concentrations in many lakes of pH below 5.5. Another effect of acidification is the increased growth of mosses and algal mats on the sediments. A further effect is a change in species composition but not necessarily a decrease of biomass of benthic organisms. This study incorporated field surveys of 6 acidic lake basins followed by artificial acidification of lake enclosures (limnocorrals) and laboratory studies with microcosms containing sediment and water from the lakes used in the field survey.

By comparing several lakes of similar pH with respect to chemistry, benthic fauna and benthic algae, rather than taking one representative lake at each pH over a range, we showed considerable variability among lakes of similar pH. Therefore we contradict some generalisations which have been made in the literataure. The occurrence of benthic algal mats is by no means restricted to, nor invariable in, acidic lakes. We question the 'oligotrophication' hypothesis put foward by Swedish scientists in the '70s, at least for the Ontario lakes which we have studied.

Aluminum is certainly released from the sediments as lakes acidify but variance in benthic biota composition is not explained by variation in Al concentrations. Epilimnetic oligochaete biomass was negativelly correlated with Al concentration. Dissolved organic carbon similarly did not substantially add to the variance in benthic composition explained by pH alone. We also showed a positive correlation between average particle size of sediments and both epi- and infaunal samples and pH. Microbial biomass in sediments was strongly correlated with chlorophyll a levels in the water column.

The findings have implications for food supplies of sediment feeding and insectiverous wildlife, whose quality and quantity of food may be diminished as lakes acidify, either directly or via habitat modification.

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Collins, N. 1985. Effects of acidification on lake benthos in Ontario. (Abstrct) Ecol. Soc. Amer., Minneapolis, Minn., June, 1985.

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FIELD OF RESEARCH / DOMAINE DE RECHERCHE
(Check one/cocher la case appropriée)

☐ Biotechnology / Biotechnologie
☐ Food-Agriculture / Alimentation-Agriculture
☐ Communications and Computers / Télécommunications et informatique
☐ Industrial Materials and Processes / Matériaux et procédés industriels
☐ Energy / Énergie
☐ Oceans / Océans
☒ Environmental Toxicology / Toxicologie de l'environnement
☐ Open / Ouvert

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Title of Project/Titre du projet: Effect of Rhizosphere pH on Release of Bound Herbicides and Pesticides

All the projected objectives of the study were realized. A relationship was established between root-rhizosphere pH and remobilization of ^{14}C prometryne residues previously designated as "bound" and immobilized from biotic cycling. The source of nitrogen available to the plants during growth was shown to elicit comparable changes in the rhizosphere pH. Large shifts were obtained with NO_3^- or NH_4^+ supplements whereas urea did not effect changes in the rhizosphere pH. The large changes mediated by supplements of NO_3^- or NH_4^+ lead to the release and uptake of previously bound herbicide. These effects were not obtained following the addition of urea supplements.

The pH changes were specific in that larger changes were obtained with soybean (Glycine max L.) than with wheat (Triticum aestivum L.). These changes led to the differential release and uptake of previously bound herbicide. More than 37% recycling was obtained with soybean and approximately 10% with wheat. Co-incident with pH changes and remobilization of formerly "bound" herbicide residues, soil microorganisms were deleteriously affected, most notably perturbed was the nitrogen fixing symbiont Rhizobium japonicum where the generation time was increased 3-fold. In Anabaena heterocyst frequency (a measure of its capacity to fix atmospheric nitrogen) was reduced. A decrease in the population growth of Chlamydomonas segnis (signalling a reduction in carbon cycling capacity) was also obtained.

This study underlines the importance of nitrogen supplement source with respect to the remobilization of previously "bound" herbicide residues. Urea should be the supplement of choice in such soils, particularly in areas where soybeans are cultivated.

Publications resulting from this research project

1. Weinberger, P. and D. Yee, 1984. The influence of nitrogen sources on root mediated changes in substrate pH. Can. J. Botany, 62: 161-162.

2. Yee, D., P. Weinberger, D.A. Johnson, and C. De Chacin, 1985. In vitro effects of the s-triazine herbicide, prometryne, on the growth of terrestrial and aquatic micro flora. Arch. Environ. Contam. Toxicol. 14: 25-31.

3. Yee, D., P. Weinberger, and S.U. Khan. The role of rhizosphere pH in the release of soil-bound (^{14}C)-prometryne residues and the influence of N-sources. Submitted to Weed Sci.

FIELD OF RESEARCH / DOMAINE DE RECHERCHE
(Check one/cocher la case appropriee)

☐ Biotechnology / Biotechnologie	☐ Communications and Computers / Telecommunications et informatique	☐ Energy / Energie	■ Environmental Toxicology / Toxicologie de l'environnement
☐ Food-Agriculture / Alimentation-Agriculture	☐ Industrial Materials and Processes / Materiaux et procedes industriels	☐ Oceans / Oceans	☐ Open / Ouvert

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Department/Departement: DEPARTMENT OF ZOOLOGY
University/Université: UNIVERSITY OF WESTERN ONTARIO
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Title of Project/Titre du projet: EFFECTS OF LEAD ON TESTICULAR ENDOCRINOLOGY IN THE DEVELOPING MALE

EFFECTS OF LEAD ON TESTICULAR ENDOCRINOLOGY IN THE DEVELOPING MALE

The toxic effects of lead at high doses have been known for a long time and a large amount of literature exists to show that high levels of lead have serious clinical effects on a number of body functions. However, the possible influences of low levels of lead have rarely been explored and essentially nothing was known about the effects of subclinical levels of lead on reproductive functions when we began our studies. We had shown previously that exposure to lead prenatally (via the placenta) and neonatally (via the mother's milk) affects steroid hormone production, the onset of sperm formation, and pituitary hormone receptors in the testis at the onset of puberty (a time when the endocrine system is particularly sensitive to environmental factors). The aims of the studies funded by this NSERC Strategic Grant were to determine (a) the minimum dose of lead to have an effect on the male reproductive system at puberty, (b) whether the lead effect is permanent, and (c) the molecular mechanisms of action of lead in the testis. The studies show that prenatal and neonatal exposure to low levels of lead, at concentrations which may not result in statistically significant increases in tissue lead, results in a significant decrease in the activity of 5-alpha-reductase, an enzyme that produces potent androgens in the testis at the onset of puberty. Our results show further that exposure to lead early in life (prenatally and neonatally) appears to have lasting effects so that steroid hormone synthesis and hormone receptors are still altered in adult life. In vitro studies employing testicular cells in culture and direct enzyme assays suggest that in the testis lead may act directly (immediate effect) by suppressing enzyme activities, and indirectly (long term effects) by reducing hormone-receptor binding and the resultant cyclic AMP and steroid enzyme production. We conclude that exposure of the young, during the developmental period, to environmental lead at levels which may be present in urban environments, could have a permanent subclinical effect which is detectable in measurements of certain testis functions.

Bibliography of Publications Resulting from this Research Project:

Wiebe, J.P., Barr, K.J., Buckingham, K.D., and Arratoon, C.D. The action of lead on the testis at the onset of puberty: cellular and molecular mechanisms. International Symposium on Health Effects and Interactions of Essential and Toxic Elements, Lund, Sweden, June 13-18, 1983.

Wiebe, J.P., Salhanick, A.I., and Myers, K.I. On the mechanism of action of lead in the testis: in vitro suppression of FSH receptors, cyclic AMP and steroidogenesis. Life Sciences 32: 1997-2005, 1983.

Arratoon, C.D. Changes in spermatogenesis and testicular endocrinology in the rat with pre- and/or postnatal lead treatment. M.Sc. Thesis, University of Western Ontario, 1984.

Wiebe, J.P., Barr, K.J., and Buckingham, K.D. The action of lead on the testis at the onset of puberty: cellular and molecular mechanisms. Nutrition Research, in press.

Several manuscripts are in preparation.

FIELD OF RESEARCH / DOMAINE DE RECHERCHE
(Check one/cocher la case appropriée)

☐ Biotechnology / Biotechnologie
☐ Food-Agriculture / Alimentation-Agriculture
☐ Communications and Computers / Telecommunications et informatique
☐ Industrial Materials and Processes / Matériaux et procédés industriels
☐ Energy / Énergie
☐ Oceans / Océans
■ Environmental Toxicology / Toxicologie de l'environnement
☐ Open / Ouvert

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Title of Project/Titre du projet: Physiological Studies on the Toxicity of Environmental Acid to Freshwater Fish, Amphibians and Crustaceans

This study has examined the toxic mechanisms by which environmental acidification kills fish, amphibians and crustaceans. While a variety of physiological processes are damaged, the one of key importance is electrolyte regulation by the gills; the fish die from a lethal loss of body salts. Elevated heavy metal levels in the water, a common correlate of acidification, exacerbate the salt loss and thereby increase toxicity. Elevated calcium levels in the water, a side effect of ameliorative 'liming', protect against salt loss, alter the nature of the toxic syndrome, and thereby reduce toxicity. While similar effects are seen in larval and adult amphibians, crayfish apparently die from acidosis and demineralization of the exoskeleton. Several simple tests diagnostic and/or predictive of acid toxicity have been developed.

1. Perry, S.F. and Wood, C.M. (1985) Kinetics of branchial calcium uptake in the rainbow trout: effects of acclimation to various external calcium levels. J. Exp. Biol. In Press October, 1984.
2. Lauren, D.J. and McDonald, D.G. (1985) Effects of water hardness and pH on Cu{++}-dependent branchial ionoregulatory disturbances in the rainbow trout, Salmo gairdneri Richardson. J. Comp. Physol. In Press, June 1984.
3. Wright, P.A. and Wood, C.M. (1985) An analysis of branchial ammonia excretion in the freshwater rainbow trout: effects of environmental pH change and sodium uptake blockade. J. Exp. Biol. In Press, May, 1984.
4. McDonald, D.G., Ozog, J.L. and Simons, B.P. (1984) The influence of low pH environments on ion regulation in the larval stages of the anuran amphibian, Rana clamitans . Can. J. Zool. In Press, March 1984.
5. Hobe, H., Wood, C.M. and McMahon, B.R. (1984) Mechanisms of acid-base and ionoregulation in white suckers (Catostomus commersoni) in natural soft water. I. Acute exposure to low ambient pH. J. comp. Physiol. B154: 35-46.
6. Spry, D.J. and Wood, C.M. (1984) Acid-base and plasma ion changes in rainbow trout during short-term toxic zinc exposure. J. comp. Physiol. B154: 149-158.
7. Hobe, H., Wilkes, P.R.H., Walker, R.L., Wood, C.M. and McMahon, B.R. (1983) Acid-base balance, ionic status, and renal function in resting and acid-exposed white sucker (Catostomus commersoni) . Can. J. Zool. 61: 2660-2668.
8. McDonald, D.G. (1983) The effects of H{+} upon the gills of freshwater fish - a review. Can. J. Zool. 61: 691-703.
9. McDonald, D.G. (1983) The interaction of environmental calcium and low pH on the physiology of the rainbow trout, Salmo gairdneri . I. Branchial and renal net ion and H{+} fluxes. J. exp. Biol. 102: 123-140.
10. McDonald, D.G., Walker, R.L., and Wilkes, P.R.H. (1983) The interaction of environmental calcium and low pH on the physiology of the rainbow trout, Salmo gairdneri . 2. Branchial iono-regulatory mechanisms. J. exp. Biol. 102: 141-155.
11. Graham, M.S., Wood, C.M. and Turner, J.D. (1982) The physiological responses of the rainbow trout to strenuous exercise: interactions of water hardness and environmental acidity. Can. J. Zool. 60: 3153-3164.
12. Milligan, C.L. and C.M. Wood (1982) Disturbances in hematology, fluid volume distribution and circulatory function associated with low environmental pH in the rainbow trout. J. Exp. Biol. 99: 397-415.

STRATEGIC FIELD: FOOD/AGRICULTURE

DOMAINE THÉMATIQUE: ALIMENTATION ET AGRICULTURE

FOOD/AGRICULTURE

Agriculture, fisheries and food are major components of the Canadian industrial milieu in terms of dollar value, people employed, foreign exchange earned and impact on the consuming public. Strategic grants in this area provide support for university research into the development of improved methods for the procurement, handling, distribution, processing and production of all food products.

Proposals should give a clear indication of benefits to agriculture, agricultural engineering, and food production industries. Note that emphasis should be placed on the socio-economic benefits which may result from the proposed research.

For purposes of this program the field has been divided into the following major subfields.

Food

This subfield includes:

- research into all areas of post-harvest food science and technology;
- improvements in food handling, preservation, and processing;
- better resource utilization;
- quality and nutritional enhancement;
- process and equipment development;
- storage, distribution, quality control and food safety.

Production

This subfield includes research on:

- improvements in production and protection of agricultural crops, animals, fish (aquaculture and mariculture), birds and insects, and their products;
- farming systems;
- equipment and infrastructures;
- research on feeds and nutrition;
- weed and pest control;
- protection against diseases in plants, fish and animals.

ALIMENTATION ET AGRICULTURE

L'agriculture, les pêcheries et l'alimentation constituent des éléments importants de l'industrie canadienne, par les revenus qu'ils produisent, les emplois qu'ils créent, les devises étrangères qu'ils rapportent et l'impact qu'ils ont sur les consommateurs. Les subventions thématiques dans ce domaine viennent en aide à la recherche universitaire en vue d'améliorer les méthodes d'approvisionnement, de manutention, de distribution, de transformation et de production de tous les produits alimentaires.

Les demandes devraient présenter une forte probabilité d'avantages pour l'agriculture, le génie rural et l'industrie alimentaire. Veuillez noter qu'on doit insister sur les retombées socio-économiques pouvant résulter du projet de recherche présenté.

Aux fins du programme ce domaine a été divisé en trois domaines secondaires.

Alimentation

Ce domaine comprend:

- les recherches sur tous les aspects de la science et de la technologie des aliments après l'étape de la récolte;
- l'amélioration de la manutention, de la conservation et de la transformation des aliments;
- une meilleure utilisation des ressources;
- l'amélioration de la qualité et de la valeur nutritive;
- la mise au point de procédés et d'équipements;
- l'entreposage, la distribution, le contrôle de la qualité et l'innocuité des aliments.

Production

Ce domaine comprend la recherche sur:

- l'amélioration des modes de production et de protection des cultures agricoles, des animaux d'élevage, des poissons (aquiculture et mariculture), des oiseaux et des insectes, ainsi que de leurs produits;
- les systèmes d'exploitation agricole;
- les équipements et les infrastructures;
- l'alimentation et la nutrition animales;
- les méthodes de lutte contre les mauvaises herbes et les insectes nuisibles;
- les mesures de prophylaxie animale (y compris les poissons) et végétale.

Resources and Environment

This subfield includes:

- the enhancement of agricultural technologies that are appropriate to Canadian conditions;

- studies of stresses on plants, animals and fish, such as pests, weather, seasonal and physiological factors, toxins and nutrient deficiencies;

- research into waste utilization, use of "waste heat", solar energy, soil depletion, soil conservation, aquaculture technology, and resource enhancement.

Some areas of special needs and opportunities for research in the science and engineering aspects of food/agriculture have been identified. Examples are:

- Innovative research aimed at enhancing the overall productivity of the food industry and increasing Canada's self-sufficiency in food.

- Development of improved processes for better use of resources and for new "value added" products from cereals, fruits, vegetables, meats, fish and dairy products.

- Investigation of the safety and nutritional quality of Canadian foods and the effects of processing.

- Development of improved methods and equipment for the preservation of food products, to increase allowable storage time while maintaining quality and nutritional value.

- Development of methods of reducing energy costs in the production, processing and distribution of foods.

- Study of soil management, including depletion of organic matter and effect of cropping systems on structure and workability.

- Investigation of climatological impacts on cropping systems, food storage, plant and animal breeding, grain conditioning, animal housing and aquaculture.

- Research on reproductive physiology, nutrition and disease as it relates to specific production systems for livestock, poultry and cultured fish.

- Development of new approaches to crop improvement (yield and quality) through photosynthesis, nitrogen fixation, genetic engineering, cell culture, etc.

Ressources et environnement

Ce domaine comprend:

- l'amélioration de techniques agricoles appropriées au Canada;

- l'étude des stress que les insectes nuisibles, les conditions météorologiques, les facteurs saisonniers et physiologiques, les toxines et la carence d'éléments nutritifs exercent sur les plantes, les animaux et les poissons;

- les recherches sur l'utilisation des déchets et de la "chaleur résiduelle", l'énergie solaire, l'épuisement des sols, la technologie de l'aquiculture et de l'amélioration des ressources.

Certains secteurs de l'alimentation et de l'agriculture ont été identifiés où il est nécessaire et opportun de faire de la recherche en sciences ou en génie. En voici des exemples.

- Recherche innovatrice visant à améliorer la productivité globale de l'industrie alimentaire et à accroître l'auto-suffisance du Canada en matière d'alimentation.

- Mise au point de meilleurs procédés en vue de mieux utiliser les ressources et en vue d'améliorer les produits obtenus à partir des céréales, des fruits, des légumes, des viandes, des poissons et des produits laitiers.

- Études sur l'innocuité et la valeur nutritive des aliments produits au Canada et sur les effets des procédés de transformation.

- Mise au point de meilleures méthodes et de meilleurs appareils servant à la conservation des aliments afin d'accroître la durée d'entreposage possible tout en maintenant la qualité et la valeur nutritive.

- Méthodes de réduction des coûts de l'énergie dans la production, la transformation et la distribution des aliments.

- Gestion des sols, y compris l'étude de l'épuisement de la matière organique et l'étude de l'effet des méthodes d'exploitation sur la structure et la texture des sols.

- Impacts du climat sur les méthodes de culture, l'entreposage des aliments, la phytogénétique et la reproduction animale, le conditionnement des grains, le logement des animaux et l'aquiculture.

- Recherches sur la physiologie de la reproduction, sur la nutrition et les maladies, lorsqu'elles portent sur des systèmes d'élevage précis pour le bétail, la volaille et le poisson d'élevage.

- Nouvelles méthodes pour améliorer les cultures (tant du point de vue quantitatif que qualitatif), en exploitant la photosynthèse, la fixation de l'azote, le génie génétique, la culture cellulaire, etc.

FOOD/AGRICULTURE/
ALIMENTATION ET AGRICULTURE

NAME/NOM DEPARTMENT/DÉPARTEMENT UNIVERSITY/UNIVERSITÉ		PAGE
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FIELD OF RESEARCH / DOMAINE DE RECHERCHE
(Check one/cocher la case appropriée)

☐ Biotechnology / Biotechnologie	☐ Communications and Computers / Telecommunications et informatique	☐ Energy / Energie	☐ Environmental Toxicology / Toxicologie de l'environnement
■ Food-Agriculture / Alimentation-Agriculture	☐ Industrial Materials and Processes / Materiaux et procedes industriels	☐ Oceans / Oceans	☐ Open / Ouvert

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University/Université: University of Toronto, Erindale Campus, Mississauga, Ont. L5L 1C6
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Title of Project/Titre du projet: Strain Improvement and Control of Mycovirus in the Cultivated Mushroom

Cultivation of the edible mushroom, Agaricus bisporus, is a multimillion dollar industry in North America and elsewhere. For example, the market value of the crop in Canada exceeds $60,000,000 annually. Despite the importance of the cultivated mushroom, little attention has been paid to genetic improvement of commercial strains. Consequently the various strains in use today have remained almost completely uniform genetically. The goal of this project was to introduce genetic variability occurring in wild species of Agaricus into cultivated strains so that strains improved with respect to yield, shelf life, disease resistance or any other parameter could be selected from the increased range of inherited variability. At the beginning of the project little was known about the genetics and breeding behaviour of Agaricus. We first collected a large number of isolates of various wild species of Agaricus and characterized the genetic systems regulating mating (1). This initial study provided information that will allow controlled crosses to be conducted in a breeding program. We then developed a means for the production and regeneration of protoplasts (1) (fungal cells whose walls have been removed enzymatically). These protoplasts may be used for the hybridization of isolates that do not normally mate with one another. In order to collect information on the extent of genetic variation of Agaricus, we first characterized the DNA of A. bisporus with respect to genome size, percent G+C, and proportion of unique and repetitive sequences (2) and then examined homologies between DNAs different species (3). Our results indicated complete genetic uniformity in cultivated strains and genetic divergence between cultivated and wild strains. Because of the potential importance of cytoplasmic genes in a breeding program, we also examined variation in the mitochondrial DNAs by using restriction endonucleases and agarose gel electrophorsis. As with the DNA homology study, genetic uniformity was found among the mitochondrial DNAs of cultivated mushrooms, and genetic diversity among wild isolates. During the course of examining mitochrondrial DNAs we discovered several plasmid-like DNAs that replicate independently of either the mitochondrial or nuclear genomes. These plasmid-like DNAs may prove extremely useful as vectors for genetic engineering. Our work has provided information which will be essential in future work on strain improvement. We have maintained contact with many Canadian mushroom growers and we are seeking additional commitment from private industry and government to continue our work.

The following publications resulted from this Strategic Grant.

1. Arthur, A., Herr, F., Straus, N., Anderson, J., Horgen, P. 1982. Characterization of the genome of the cultivated mushroom, Agaricus brunnescens. Experimental Mycology 7:127-132.
2. Horgen, P., Arthur, R., Davy, O., Moum, A., Herr, F., Straus, N. and Anderson, J. 1984. The nucleotide sequence homologies of unique DNAs of some cultivated and wild mushrooms Canadian Journal of Microbiology, 30:587-593.
3. Anderson, J., Petsche, D., Herr, F. and Horgen, P. 1984. Breeding relationships among several species of Agaricus. Canadian Journal of Botany, 62:1884-1889.
4. Mohan, M., Horgen, P., Anderson, J. In press. Heterogeneity in the mitochondrial genomes of Agaricus species. Current Genetics.
5. Mohan, M., Anderson, J. and Horgen P. 1984. Characterization of a Novel Plasmid in the Economically Important Cultivated Mushroom. Current Genetics 8:615-619.

FIELD OF RESEARCH / DOMAINE DE RECHERCHE
(Check one/cocher la case appropriee)

- ☐ Biotechnology / Biotechnologie
- ■ Food / Aliments -Agriculture
- ☐ Communications and Computers / Telecommunications et informatique
- ☐ Industrial Materials and Processes / Materiaux et procedes industriels
- ☐ Energy / Energie
- ☐ Oceans / Oceans
- ☐ Environmental Toxicology / Toxicologie de l'environnement
- ☐ Open / Ouvert

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Title of Project/Titre du projet: "Ovipositional Semiochemicals in the Management of Insect Pests"

Cone-moths deposit an egg in a cone-flower (conelet). As the cone develops the egg hatches and the larva feeds resulting in the destruction of the seed. Economically this damage is of concern in conifer seed-orchards.

As an exploration of the possibility of managing phytophageous insect pests by disruption of their ovipositing, a study was begun of the chemical basis of the location of conelets by gravid female cone-moths. An examination of the volatiles of the conelets of Engelmann, White, and Sitka spruce, and Douglas fir resulted in their characterisation as complex blends in which monoterpenoids predominate. The attractivity of these volatiles, and synthetic mixtures to female moths is now under investigation.

FIELD OF RESEARCH / DOMAINE DE RECHERCHE
(Check one/cocher la case appropriée)

☐ Biotechnology / Biotechnologie
■ Food-Agriculture / Alimentation-Agriculture
☐ Communications and Computers / Telecommunications et informatique
☐ Industrial Materials and Processes / Materiaux et procedes industriels
☐ Energy / Energie
☐ Oceans / Oceans
☐ Environmental Toxicology / Toxicologie de l'environnement
☐ Open / Ouvert

Name/Nom: Betteridge, K.J., Guay, P., Goff, A.K., Bousquet, D., Tremblay, A., King, W.A., et Guillomot, M.
Department/Département: Centre de Recherche en Reproduction Animale
University/Université: de Montréal
Phone number (optional)/N° de téléphone (facultatif): (514)773-8521 poste 221
Title of Project/Titre du projet: A study of the establishment of pregnancy and of factors leading to embryonic mortality in cattle.

A multidisciplinary team approach has been taken to this study of early pregnancy in cattle with the objective of understanding, and thence reducing, embryonic loss which is estimated to cost the Canadian livestock industry $39 million annually. Embryos have been collected regularly from superovulated donors for study of their anatomical structure, chromosomes and ability to produce hormones and other products when cultured in the laboratory ("in vitro"). Important new information on chromosomal abnormalities which can lead to embryonic death has been obtained. The in vitro studies have added to our knowledge of which embryonic products are likely to be essential for pregnancy to continue, and also of how uterine cells help embryonic growth. Methods have been refined to the point where glucose uptake (for example) of individual embryos can be measured, offering the prospect of estimating the viability of embryos. By "splitting" embryos in two under the microscope, it has been possible to examine one half of the embryo in the laboratory while the other half is transferred to a recipient cow either immediately or after storage in liquid nitrogen. This will be useful in comparing the results of laboratory tests of viability with the proven viability of transferred embryos. New methods of collecting urine continuously have been developed so that the secretion of prostaglandins can be monitored during early pregnancy. This should allow comparison of the patterns of production of this hormone during normal pregnancy with what happens when a pregnancy fails. It has been confirmed that one cause of pregnancy failure could involve selective death of the cells from which the embryo itself develops, while the cells producing the fetal membranes continue to grow and establish a "pregnancy" without an embryo. The ways in which early embryonic membranes attach to the uterine wall have been studied by electron microscopy. Special computer programmes have been developed for efficient management of the animals used in these studies and of the experimental data that they have generated.

Key publications resulting from these studies are listed below and the inyestigators will be pleased to provide more complete information on request.

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FIELD OF RESEARCH / DOMAINE DE RECHERCHE
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☐ Biotechnology / Biotechnologie	☐ Communications and Computers / Telecommunications et informatique	☐ Energy / Energie	☐ Environmental Toxicology / Toxicologie de l'environnement
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Title of Project/Titre du projet: Predicting Drought-Stress Tolerance.

New crop lines must be subjected to expensive and time-consuming field-trials to determine if they are suitable for widespread planting, particularly in areas which have limited water availability.

Prior to the completion of this project there were no reliable data available which could be developed into a laboratory-oriented screening test for the tolerance to drought of different cultivars and species of crop plants. In the course of our studies we have found that when young maize seedlings are subjected to water-stress, as well as a variety of other stresses (heat-, hormone- and wounding-stress) they produce a particular set of proteins which can be identified by sophisticated protein separation techniques. Moreover, using modern biotechnological methods, the activity of the gene for these proteins can be monitored. These methods can now be refined to determine the universality of this molecular response to stress, with the aim of quantitating the relationship between stress-tolerance and the magnitude of response. As the leaves of barley plants turn green they produce large quantities of a key photosynthetic enzyme: ribulose-1,5-bisphosphate carboxylase/oxygenase. In drought-susceptible cultivars of barley the activity and stability of this enzyme is considerably more reduced under water-stress conditions than it is in drought-tolerant cultivars. There appears to be considerable potential for using this enzyme as a marker of tolerance. This may be achieved by screening young barley seedlings in laboratory tests, thus circumventing the need for extensive and expensive field trials.

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Formule 145 (1984)

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■ Food-Agriculture / Alimentation-Agriculture
☐ Industrial Materials and Processes / Matériaux et procédés industriels
☐ Oceans / Océans
☐ Other / Divers

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tle of Project/Titre du projet:

Mathematical Model of Oxytetracycline Residues in Swine Tissues.

Mathematical models were developed which described the uptake, distribution and elimination of an antibiotic widely used in swine. A 3-compartment model described the distribution and elimination processes for all routes of administration. A 4-compartment model with absorption, described total drug movement after oral and intramuscular administration.

Mathematical models were used to determine drug withdrawal periods. Two approaches were examined. One gave a withdrawal time based on urine levels of 16 days and on tissue levels of 7.9 days. The second method gave a withdrawal time of 11.1 days.

It was demonstrated that the identification of a residue in a single sample tissue could allow estimation of residue levels in other tissues. Kidney proved to be the best tissue for predicting residue levels in edible tissues.

Endotoxin administration dramatically changed distribution of oxytetracycline on animals after intravenous administration. Uptake of drug from injection sites was delayed when the drug was given intramuscularly. However the disease appears to have little effect on long term residues.

Haemophilus pneumonia altered both the distribution and elimination of antibiotics in animals but would also appear to have little effect on drug residues and withdrawal times.

Publications

W.D. Black and R.D. Gentry. Tissue Distribution of Oxytetracycline in Swine Following Single Oral Dose Administration. Can. Vet. J. 25: 158-161, 1984.

R.D. Gentry, W.D. Black and C.C. Travis. Practical Aspects of Pharmacokinetics Model Identification and Parameter Estimation Subject to Experimental Constraints. In Biomathematics and Cell Kinetics, ed. Manuel Rotenberg, Elsevier/North Holland, Biomedical Press, BV. 1981.

W.D. Black and R.D. Gentry: Pharmacokinetics of Oxytetracycline in Swine: Intravenous and Oral Administration. Fed. Proc. Vol. 41, No. 4, #6222, 1982.

Publications in Preparation

W.D. Black and R.D. Gentry. Selection of Samples for Monitoring of Drug Residues in Pork: Predictive Model of Residues in Edible Tissues. (For Canadian J. of Comp. Med.)

R.D. Gentry and W.D. Black. The Effect of Endotoxaemia on the Elimination of Oxytetracycline from Swine, Following Oral and Intravenous Administration. (For Can. J. Comp. Med)

R.D. Gentry and W.D. Black. The effect of Haemophilus Pneumonia on the Elimination of Oxytetracycline From Swine Following Intramuscular Treatment. (For Can. J. Comp. Med.)

W.D. Black and R.D. Gentry. The Elimination of Oxytetracycline From Swine Tissues Following Oral Administration Via the Feed. (For Canadian Vet. J.)

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☐ Energy / Energie
☐ Oceans / Oceans
☐ Environmental Toxicology / Toxicologie de l'environnement
☐ Other / Autre

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Title of Project/Titre du projet Factors Affecting Benomyl Degradation

Benomyl, methyl 1-(butylcarbamoyl)-2-benzimidazolecarbamate, has been one of the most widely used systemic fungicides for more than 10 years. Its mode of action, however, is still not well understood because its natural degradation compound, methyl 2-benzimidazole-carbamate (MBC or carbendazim) is also fungitoxic. Consequently, it was extremely difficult to determine the roles of the two chemicals after spray application. It is generally believed that although the fungicide is applied as benomyl, the actual fungicidal activity derives from MBC. MBC was believed to be produced in aqueous media soon after benomyl is sprayed. However, some of these understandings have been brought up as a result of mis-interpretation of experimental results. The greatest problem in elucidating the mode of action has been in the lack of understanding about the behavior of benomyl in solvents and suitable analytical methods for intact benomyl and MBC. In this research work some signif-icant findings have been brought up and several comprehensive analytical methods have been developed.

Solubility of benomyl in water at a pH range of 1 - 13 was investigated. The solubility was low being 1.8 - 4.0 ug/ml in the pH range of 3 - 10, but much higher at pH 1 and at pH greater than 11. At pH 13 no benomyl was found as a result of its quantitative conversion to 3-butyl-2,4-dioxo[1,2-a]-s-triazinobenzimidazole (STB) within 30 minutes. MBC was found in all the solutions prepared, but BBU, 1-(2-benzimidazolyl)-3-n-butylurea, was found only in highly alkaline solutions. The degradation of dissolved benomyl at pH 7 was rather slow at room temperature. When refluxed at 100°C for 2 hrs, however, benomyl converted to MBC, most of which then converted to 2-aminobenzimidazole (2-AB) at pH 9. In contrast, at pH 13 and 14, benomyl converted to STB, which then converted to BBU; under the condition, MBC present in the sample quantitatively converted to 2-AB.

Based on the above findings a basic HPLC method has been developed and several other modified methods have been developed to meet specific conditions of samples and purposes of analyses. In the most basic method, benomyl is quantitatively converted to STB at pH 13 and determined as STB, while MBC, unaffected under the above condition, is determined as MBC. This method is applicable for analyses of benomyl and MBC in most aqueous samples. Minor modifications have been made for analyses of formulated benomyl products (Benlate) and sample solutions prepared for pathological studies. For analyses of residues of benomyl and MBC in crops benomyl is converted to BBU, and MBC is converted to 2-AB.

By preparing benomyl test solutions carefully and tracing the concentration of intact benomyl in the solution, its biological activities were compared with those of MBC and several other fungicides. Benomyl inhibited the respiration of yeast and the fermentation of glucose, but MBC did not. In contrast, butylisocyanate, another degradation product of benomyl, strongly inhibited the yeast respiration. It is expected that many assumptions made re the biological activities of benomyl in the past, may be changed if further exper-iments are conducted with the proper preparation of sample solutions and proper tracing of benomyl concentrations in test solutions.

As a result of the above study, one paper is in press and 6 other papers are being prepared for publication.

Solubility of benomyl in water at different pH's and its conversion to methyl 2-benzimid-azole carbamate, 3-butyl-2,4-dioxo[1,2-a]-s-tranzinobenzimidazole and 1-(2-benzimidazolyl)3-n-butylurea. R.P. Singh and M. Chiba. J. Agric. Food Chem. in press.

FIELD OF RESEARCH / DOMAINE DE RECHERCHE
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Title of Project/Titre du projet: A pathophysiological model for stress characterization in swine.

A condition in market-sized pigs referred to as porcine stress syndrome (P.S.S.) has been increasingly associated with economic losses. Both deaths and reduction in the quality of retail pork contributes to this loss. The postmortem findings are limited and recent findings suggest a genetic predisposition in some cases. Knowledge of the pathophysiologic mechanisms of this disease syndrome is incomplete. Symptomatic drug therapy has been unsatifactory. It is obvious that the etiology of the syndrome is multifaceted and in order to provide better therapeutic and field recognition systems a basic understanding of the reaction of swine to a controlled stress situation must be provided. The clinical deaths are associated with cardiac failure, and the few pathological lesions point to a peripheral cardiovascular control failure.

The immediate objectives of the project were to establish a repeatable hemorrhagic shock procedure, in which a predictable degree of stress was applied to each animal; to evaluate and record the various biochemical, cardiovascular, coagulation, endocrine and tissue pathological changes that occur, and compare them with the observed stress changes previously described in swine: to subject stress-sensitive animals and stress-resistant swine to the established hemorrhagic shock procedure and compare their reactions to those of normal swine: to identify the organ or system producing sudden death or tissue pathology in swine following stress and through supportive therapy reduce the losses due to "sudden death" or poor meat quality.

The data accumulated indicated the trends involved in describing the characteristics of a hemorrhagic shock procedure in swine.

The method was reproduceable, provided a characteristic repeatable pattern of stress in a laboratory setting using a modified Wiggers procedure with a Lamson pressure bottle. The mortality developed by a hemorrhagic stress where the blood pressure is maintained at 45-50 mm.Hg for 120 min. is 70% and provides a level for statistical comparison with groups of swine that are stress-resistant or stress-susceptible. The stress of hemorrhage produced many of the ante-mortem and post mortem characteristics of animals subjected to transport or environmental stress as observed at packing plants. Necropsy examination indicated that lung and cardiac lesions were prominent and that gastric erosion and ulcers were the primary lesions of the gastro-intestinal tract. No single parameter change, other than a rapid drop in blood pH to the 6.9 level or respiratory failure during the procedure could be related to the mortality.

The ham muscles were cut across in all animals at necropsy. The muscle was examined for gross evidence of abnormal colour, swelling or fluid extravasation. Normal muscle was observed in 73.4%. Areas of pale muscle in the subcutaneous layers with normal colour in deep zones were observed in nine of 34 animals. No real evidence of pale, soft, edematous meat (P.S.E.) could be observed.

Boars that were believed to be stress-susceptible (malignant hyperthermia positive) were subjected to the standard stress method along with a limited number of their siblings (not Halothane tested) and no significant difference in their reaction to stress, from the controls could be observed.

A group of swine were provided with Cortisol (.03 mg/kg) immediately prior to the test period. Cortisol has been shown to produce "stress resistance" when administered prior to the stress period. No significant differences in the various parameters measured were seen. The mortality was improved and the gastrointestinal and cardiac lesions were reduced.

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- [ ] Energy / Energie
- [ ] Oceans / Oceans
- [ ] Environmental Toxicology / Toxicologie de l'environnement
- [ ] Open / Ouvert

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Title of Project/Titre du projet: Control of Snow Mould Growth

The net productivity of overwintering crops is determined by two major factors: (1) plant cold-hardiness or the ability of plants to survive freezing temperatures and (2) the absence of infection by psychrophilic plant pathogens called snow moulds. Classical approaches to the control of snow moulds, breeding and chemical treatment, have been rather unsuccessful. It is my belief that eventual control of these pathogens will come through a greater understanding of these fungi and their infection process. These organisms are unique biologically in that they do not grow vegetatively (this is the infectious form of these fungi) when subjected to temperatures of between 20° and 30°C. Thus, we concluded that an understanding of the mechanism by which normal temperatures limited the growth of the infectious form could lead to insights through which we could effectively control these pathogen fungi. Initially, we investigated the possibility of the production and excretion of a temperature-induced chemical or chemicals which would inhibit growth and development of the infectious state. The results conclusively showed that temperature indeed did induce these organisms to excrete small molecular metabolites capable of affecting growth. However, the effects observed were inhibitory or stimulatory to the growth of the infectious state depending on the fungal species examined. Since this approach did not lead to a specific growth inhibitor, it was concluded that an in depth analysis of temperature regulation of fungal growth was warranted. It was observed that in all sclerotial forming species examined (ie. those snow moulds capable of transformation from an infectious state to a dormant, protective state called a sclerotium) non-permissive temperature induced vegetative hyphae to accumulate specific proteins associated with mature sclerotia. Thus, we now have a potent tool (ie. these proteins) for understanding the molecular mechanism for the transformation of the infections state to the dormant sclerotial state. Further investigations are continuing in order to understand this transformation more fully with the purpose of eventually controlling these pathogenic fungi by inhibiting this essential transformation process.

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Title of Project/Titre du projet Evaluation of traits associated with photosynthetic productivity in wheat

Wheat breeding in many countries has been remarkably successful in increasing grain yields during the past 20-30 years. The increases have resulted largely from changes in the distribution of dry matter between the stem and the grain, with less going to the stem and more to the grain, and not from increases in the total production of dry matter (biomass) through photosynthetic activity. There is evidence that the possibilities for changing the distribution of dry matter are now coming to an end, and that future increases in grain yield will have to result from improvements in the photosynthetic activities of the crop. Plant breeders will thus have to direct more effort to increasing photosynthesis than in the past, and they will need to have information on the best approaches to follow, and on the best source of genes for use in their controlled hybridizations between different strains. This project was designed to supply breeders of Canada's most important crop with some of the required information, and with some strains that could serve as parents in their hybridizations.

Over 150,000 different varieties and breeders lines were examined for good expression of traits which are likely to be associated with photosynthetic productivity. A number of varieties/ lines were selected for good expression of traits thought either to reflect the amount of photosynthetic machinery present in an individual leaf, or to indicate the amount of productive leaf surface that could be present in a crop canopy. These selections have been incorporated in a morpho-physiological nursery, seed of which is being distributed to interested wheat breeders.

Studies to evaluate the relationships of the various traits to photosynthetic productivity have shown that one of the individual leaf traits is well correlated with photosynthetic activity, and that it is generally associated with high productivty in a crop situation. Studies of the ways in which leaves are arranged in a crop, which affects the amount of leaves exposed to sunlight have emphasized that the arrangement thought most desirable (erect leaves) is most difficult to achieve consistently throughout the growing season. Some varieties which hold their leaves erect throughout most of the growing season have been discovered, however, and studies with others are continuing.

The information and the new strains made available from the project will help Canadian wheat breeders in their efforts to produce new improved varieties. New varieties are necessary to help the Canadian farming community remain competitive in a world in which our competitors have been, and show every sign of continuing to be, successful in improving the productivity of their own plant varieties.

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Title of Project/Titre du projet: Prevention of mycotoxin production in corn

SUMMARY

One of the most prevalent ear mold fungi attacking corn is Fusarium graminearum (perfect stage Gibberella zeae). Infection of grain corn by this fungus can lead to the contamination of the grain by mycotoxins. Two of the more common mycotoxins are vomitoxin and zearalenone. Swine are particularly susceptible to the mycotoxins produced by F. graminearum. The toxins can have a deleterious effect on reproduction, feed intake and digestion. The presence of mycotoxins in corn utilized in the industrial processes or for export can also be a problem.

The objectives of this research are to

i) produce corn populations resistant to this mold
ii) determine the genetic nature of the resistance
iii) determine morphological traits that relate to resistance

Two populations have gone through a cycle of each of half sib and S_1 *per se* improvement for resistance to infection and growth of Fusarium graminearum ear mold. Evaluations of date indicate that S_1 *per se* selection is more efficient than half sib selection.

The inheritance of F. graminearum ear mold resistance was investigated. The studies confirmed a large genotype x environment interaction. Heritability estimates were low with additive effects accounting for the largest part of genetic variability. Studies indicate that a single virulent strain should be adequate for resistance screening.

An examination of plant characteristics thought to be associated with resistance reveals that plants with loose husks and pendant ears just prior to grain harvest had less mold damage than those with tight husks and upright ears. There was no clear-cut relationship between pericarp thickness and susceptibility to the fungus. Flint versus dent endosperm types did not vary from reaction to F. graminearum.

LIST OF PUBLICATIONS

Refereed publications

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Conference proceedings

Hunter, R.B. and G.N. Atlin. 1983. Breeding for Gibberella ear mold resistance in corn. In Proc. Thirty Eighth Northeastern Corn Improvement Conference, New York, Feb. 11-12, pp. 111-113.

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Sutton, J.C., L.G. Young, R.B. Hunter, T.K. Smith and R. Ewing. 1983. Moldy feeds and swine diseases. O.M.A.F. Factsheet 83-031.

Titles of sections in books

Hunter R.B. and J.C. Sutton. 1984. Plant resistance and environmental conditions in Mycotoxins: A Canadian Perspective. National Research Council of Canada publication No. 22848 of the Environmental Secretariat.

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- ☐ Oceans / Ocean
- ☐ Environmental Toxicology / Toxicologie de l'environnement
- ☐ Open / Ouvert

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Title of Project/Titre du projet: Physico-chemical and Engineering Studies of Ultrafiltration and Reverse Osmosis for Food Processing

The main research objective was to study variables determining the membrane processing performance (flux, decline of flux on duty, membrane selectivity) as related to properties of the liquid being processed (pH, viscosity, component concentration, extent of protein denaturation) and to process control variables (temperature, pressure, flow-rate). Experiments were carried out, using UF membranes at a wide range of processing pressures covering both UF and RO conditions, with distilled water, model lactose and whey protein solutions, cottage cheese whey, buttermilk, blood, hemolysed blood, blood plasma and others. In processing of cottage cheese whey, increasing the processing pressure from 0 to 30 bar increased the permeate flux, however the increase was non-linear and serious membrane compaction effects were encountered. Only at the lowest processing pressures (0-3 bar) the effects of fouling exceeded those of membrane compaction. The permeability of the membrane used was not affected, as evidenced by constant lactose flux at pressures greater than 10 bar. Water flux increased within the whole range of processing pressures, resulting in progressively lower total solids concentrations of the permeate (1). Heating the whey at pH 6.5 and 98°C did not decrease the flux despite the heavy whey protein precipitation. Centrifuge separation of sedimentable matter improved the flux (2). Whey processing by UF membranes at RO pressures may substantially increase the efficiency of the process if the same relationships and no detrimental effects will be confirmed in long-range processing studies. Hemolysis of bovine blood substantially improved flux over that of regular blood. The differences in viscosity of the whole blood, lysed blood and blood plasma were positively correlated to flux variations. Blood plasma showed the highest viscosity and the lowest flux at comparable total solids concentrations. For preparation of blood protein concentrates by ultrafiltration it is recommended that the blood be hemolysed first (3). Various cleaning compounds exhibited highly variable effects on flux of virgin membranes, with increases of 100% or more observed in several cases. The postulated detergency effect persisted for up to one hour. Further research may lead to suggestions for process design changes resulting in improved flux rates (4). A hydrodynamic model (5) developed for characterization of the plate-and-frame membrane processing system used proved of little value in explaining the various interrelationships observed in these studies. An automated data recording system based on solenoid valve control of each membrane sandwich (6) was assembled for easier data acquisition.

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Department/Département: Nutritional Sciences
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Phone number (optional)/N° de téléphone (facultatif): (416) 978-4752 or 2747
Title of Project/Titre du projet:

Human nutritional studies to promote the use of leguminous seeds

The strategic importance of the legume project was seen as: (1) definition of the likely overall benefit of increased consumption of legume foods on public health (2) Dissemination of this knowledge to the medical, scientific and lay public such that the increased awareness will stimulate (3) increased demand for legume and legume products. This in turn will encourage growth in the relevant sectors of the food industry and agriculture, and create potential for development of a valuable export market. In this way the project was intended to have both public health and economic impact.

During tenure of the grant we developed a unique system for testing the physiological effects of foods in terms of human nutrition. This was achieved through a cycle of procedures involving detailed food analysis in tests involving human digestive enzymes to determine differences in the rate of digestion between foods prior to testing in man. These "test-tube" tests were shown to be able to predict the results of subsequent tests carried out in volunteers to determine how high and how rapidly foods raise the blood glucose. The studies provided information on digestibility and health related effects associated with alterations in fat, protein and carbohydrate metabolism. Such an approach was only possible because of collaboration of investigators from a wide range of disciplines. Our studies established that legumes were an excellent source of "sustained release" nutrients (starch and protein) (1-5, 7-11). We demonstrated that the factors responsible for this included the food form, particle size, nature of the starch, the starch protein interaction, dietary fibre, and certain of the so called antinutrients (7-10). These findings were both of scientific and strategic importance. They indicated the value of legumes in the maintenance of good health (1-5, 11) and the treatment of certain diseases e.g. diabetes (2,5), high blood lipids (1) and liver disease (11). Our published work has both supported and been used to formulate the advice given by international and national agencies concerned with health that consumption of such foods as legumes be increased (12-14). Public interest and awareness has been greatly increased through the media coverage given to our scientific work by press, radio and television. In the prosecution of our studies we have liaised with the food industry, growers and government institutions. As a result NSERC has established through our group a resource for studies on the relationship of food and physiological responses to be used by industry and government alike. We have been fortunate in achieving much during the legume project and believe that our work is helping to create the demand for legumes and legume products both at home and abroad.

1) Jenkins, D.J.A., et al. Am. J. Clin. Nutr. 1983;38:567. 2) Jenkins, D.J.A., et al. Diabetologia 1983;24:257. 3)Jenkins, D.J.A., et al. Diabetologia. 1982;22:450. 4) Jenkins D.J.A., et al. Am. J. Clin. Nutr. 1984;40:971-981. 5) Jenkins, D.J.A., et al. Am. J. Clin. Nutr. 1984;40:1175-1191. 6) Doll, R, peto, R. J.N.C.I.: 1981;66:1983. 7) Yoon, et al. Am. J. Clin. Nutr. 1983;38:835. 8) Thompson, L.U. J. Food Sci. 1983;48:235. 9) Rea, R.L., et al. Nutr. Res. 1984 in press. 10) Thompson, L.U., et al. Am. J. Clin. Nutr. 1984;39: in Press. 11) Jenkins, D.J.A., et al. Clin. Sci. 1984;66: in Press. 12)Special Report Committee Guidelines for the nutritional management of diabetes mellitus. J. Can. Dietet. Assoc. 1981;42:110-118. 13) Expert Committee on dietary carbohydrates of the ADA. Diabetes Care, 1984. 14) The Nutrition Sub Committee of the BDA Medical Advisory Committee. Hum. Nutr: Appl. Nutr. 1982;36A:378-394.

(Check one cocher la case appropriee)

☐ Biotechnology / Biotechnologie
■ Food-Agriculture / Alimentation-Agriculture
☐ Communications and Computers / Telecommunications et informatique
☐ Industrial Materials and Processes / Materiaux et procedes industriels
☐ Energy / Energie
☐ Oceans / Oceans
☐ Environmental Toxicology / Toxicologie de l'environnement
☐ Open / Ouvert

Name/Nom: J. Buchanan-Smith, T. Daynard, J.C. Jofriet (Coord.)
Department/Departement: Depts. of Animal and Poultry Science, Crop Science, and School of Engineering
University/Université: Guelph
Phone number (optional)/N° de telephone (facultatif): 824-4120 Ext. 2438 (519)
Title of Project/Titre du projet: Engineering, agronomic and nutritional aspects of ensiling low dry matter corn in cool season environments.

Corn has the potential for producing high yields of digestible dry matter for livestock feed. The continued introduction of earlier maturing hybrids permits the expansion of the corn producing area into lower heat-unit regions of Canada. The objective of this project was to study problems associated with growing corn in cool season environments in an integrated effort involving engineering, agronomic, and livestock nutrition.

Corn trials were carried out in Northern Ontario (Nipissing, Temiskaming, Rainy River, Echo Bay, Thunder Bay Districts). Muldoon and Daynard have reported on the results of these trials (1982 and 1984). Grain corn production as a cash crop is not feasible with hybrids available at present; the outlook for corn silage production is good. Problems are the lack of information to farmers, poor weed control and generally poorly drained land. The corn would normally be immature when harvested and the silage wetter than normal.

There are engineering problems associated with the storage of wet silage in tower silos. Saturated silage required silos to be designed for the additional liquid pressures. Total pressures would be greater than those specified in the Canadian Farm Building Code at present. Lau and Jofriet (1983) and Negi and Jofriet (1984) have recommendations.

Low dry matter corn makes reasonably good silage. The proportion of non-protein nitrogen is higher than normal. This problem may be aggravated by effluent losses. A possible solution is treatment with ammonia. Feeding low dry matter corn silages will require supplementation with protein to counteract this problem. Feeding value can be maximized by treating the silage with ammonia and supplementation with sodium hydroxide treated soybean meal.

REFERENCES

Lau, A. and J.C. Jofriet. 1983. Liquid pressures in tower silos. NAR-ASAE Annual Meeting, Newark, Delaware, No. NAR83-410.

Muldoon, J.F. and T.B. Daynard. 1982. Report on corn trial in Northern Ontario in 1981 and 1982. Dept. of Crop Science Report, Univ. of Guelph.

Muldoon, J.D. and T.B. Daynard. 1984. Evaluation of corn hybrids in Northern Ontario. Department of Crop Science Report, Univ. of Guelph.

Negi, S. and J.C. Jofriet. 1984. Lateral pressures in farm tower silos. Scheduled for publication in ASAE Trans. in early 1984.

SUMMARY OF COMPLETED RESEARCH PROJECT / RÉSUMÉ DU PROJET DE RECHERCHE TERMINÉ

Strategic Field / Domaine thématique:

Name of Grantee / Nom du bénéficiaire: Stephen D. Morgan Jones

Department and University / Département et université: Animal and Poultry Science, University of Guelph

Phone Number (optional) / N° de téléphone (facultatif):

Title of Project / Titre du projet: The role of carcass composition on meat quality in beef cattle.

One hundred and eighty beef steers of three different biological types (early fattening, late fattening, dairy) were fed either a conventional finishing diet (corn silage, high moisture corn) or an all forage diet (corn silage, alfalfa silage) to appetite. Steers were slaughtered to give carcasses which ranged widely in composition (10%-30% fat). Efficiency of feed conversion to live weight gain to produce carcasses of 20% fat (present market requirements) was similar for all three cattle types, although market live weights differed widely. Feed efficiency was substantially reduced for cattle fed all forage diets to those fed a conventional finishing diet. Carcasses from dairy cattle contained less lean (3%) meat than those from beef cattle although diet had no significant effect on lean tissue yield. It was found that carcasses within a grade could vary in lean content by as much as 15%. The meat quality results from this study indicated that fat had a minor influence on meat tenderness, but did influence the development of meat flavour. Carcasses with a fat content below 20% tended to produce meat with a bland flavour. Although there is a strong economic incentive to produce very lean producing carcasses of 15% fat instead of 20% fat), the results of this study would suggest that it would be associated with a decline in traditional quality and probably a reduction in cosumer acceptability. Composition data was also collected on selected cooked beef roasts and steaks. In comparison with presently available nutritional information meat cuts from Al carcasses contained substantially less fat. Several completely trimmed beef cuts have similar lipid values to those of chicken and fish. The following conclusions were made from this study: 1. The production of leaner carcasses (15% vs 20% fat) would lead to a 20% improvement in energy utilization in beef production systems. It would also mean that cereal grains could be eliminated or reduced in beef diets. However, this strategy would lead to a decline in the acceptability of beef. Research should now be directed to increase the acceptability of very lean beef. 2. Present grading procedures were found to be quite unprecise in determining actual carcass value. 3. Most cooked beef cuts were found to have much lower fat contents than those given in published nutritional tables.

FIELD OF RESEARCH / DOMAINE DE RECHERCHE
(Check one/cocher la case appropriee)

☐ Biotechnology / Biotechnologie	☐ Communications and Computers / Telecommunications et informatique	☐ Energy / Energie	☐ Environmental Toxicology / Toxicologie de l'environnement
■ Food-Agriculture / Alimentation-Agriculture	☐ Industrial Materials and Processes / Materiaux et procedes industriels	☐ Oceans / Oceans	☐ Open / Ouvert

Name/Nom: G.J. King and J.S. Walton
Department/Département: Animal and Poultry Science
University/Université: University of Guelph
Phone number (optional)/N° de telephone (facultatif): (519) 824-4120 Ext. 3658 and 3706
Title of Project/Titre du projet: FACTORS AFFECTING ESTROUS BEHAVIOUR IN DAIRY COWS

The purpose of this project was to outline some of the endocrine and environmental factors which regulate the expression of estrous behaviour by dairy cows. The experiments were conducted using cows which were kept in two different situations which reflect normal commercial conditions. During the course of this research a number of conclusions with tangible benefits were identified.

1. The use of a steroid-treated ovariectomized cow model demonstrated that for cows to manifest satisfactory signs of estrus, a period of pre-conditioning by progesterone was important. Cows which were supplemented with progesterone prior to estradiol treatment had a more intense period of estrus than those which were not.

2. In cows held under tie stall conditions, the following parameters were investigated for their ability to predict when cows were in estrus; (a) low progesterone - was accurate in predicting the day of estrus but lacked precision. (b) The ratio between maximum and minimum milk yield within days - a drop in milk yield at either the morning or the evening milking was one of the best indicators of estrus. (c) Body temperature - there was a significant increase in body temperature on the day of estrus. This was not specific to the day of estrus since increases in temperature periodically occurred at other times. (d) Feed intake - there was a small drop in feed intake on the day of estrus; this was not an efficient predictor of estrus. (e) General motor activity - cows in estrus were more active during the night preceding the day of estrus. Changes in position were observed with increased frequency. (f) A combination of parameters (b-f) - increased the accuracy of determination of the day of estrus but drastically reduced the number of estruses predicted.

3. The use of prostaglandin $F_{2\alpha}$ ($PGF_{2\alpha}$) to induce estrus was employed in a third experiment which attempted to contrast the estrous behaviour of cows injected with $PGF_{2\alpha}$ to show estrus either in the daytime or at night. Previous research indicated that there is more estrous behaviour at night and this trial was conducted to determine whether this was due simply to the environment or to some circadian oscillator. There was an advantage of treatment with $PGF_{2\alpha}$ in the evening. Cows treated in the evening had a more synchronized response to treatment and initiated estrous behaviour during the night. Cows treated in the morning tended to show estrus at any time of the day. It would appear, therefore, that treatment with $PGF_{2\alpha}$ in the evening is more likely to coincide with a natural tendency for cows to show estrus and ovulate at night.

Publications:

Walton, J.S. and King, G.J. The effect of progesterone pretreatment on estradiol-induced estrous behaviour in ovariectomized cows. Proceedings of the 10th International Congress on Animal Reproduction and Artificial Insemination, University of Illinois, June 1984.

Walton, J.S. and King, G.J. 1985. Indicators of estrus in Holstein-Friesian cows housed in tie stalls. Abstract submitted to the American Dairy Science Association Annual Meetings, June 1985, University of Illinois, Urbana.

Walton, J.S., Veenhuizen, L.P. and G.J. King. 1985. Relationships between time of day, estrous behaviour and the preovulatory LH surge in Holstein-Friesian cows after treatment with $PGF_{2\alpha}$. Abstract submitted to the American Dairy Science Association, June 1985.

SUMMARY OF COMPLETED RESEARCH PROJECT / RESUME DU PROJET DE RECHERCHE TERMINE

Strategic Field / Domaine thematique: FOOD/FISHERIES

Name of Grantee / Nom du beneficiaire: P.A. Larkin, J. D. McPhail, C.F. Wehrhahn and C.C. Lindsey

Department and University / Departement et universite: Animal Resource Ecology University of B.C.

Phone Number (optional) / No de telephone (facultatif): (604) 228-3370

Title of Project / Titre du projet: The Coho Populations of the Strait of Georgia Region: Implications for Management

Coho populations in streams tributary to the Strait of Georgia are usually remarkably similar in geographically close streams, but there are some broad geographic differences and some examples of local uniqueness. This pattern of differences, reflected in electrophoretic, meristic, morphological, physiological and behavioral characteristics is in part genetically based and adaptively significant.

There are thus substantive genetic grounds for exercising considerable caution in the transfer of stocks of coho salmon from one river system to another. For example, it might be expected that the transfer of coho from the coastal area to streams in the interior of the Fraser drainage might not be successful because the timing of seaward migration was inappropriate. Moreover, if there were interbreeding between the introduced fish and the residents, a measure of "genetic pollution" might occur to the detriment of the resident stock.

But some transplanting of stocks within areas may be done with relative impunity. The degree of stock differentiation and genetic diversity is not great by comparison with other species of fish (including salmonids) and stocks in streams in a local area may be virtually inseparable. At the same time, it is important to caution that even within local areas there may be sharp differences between stocks. It is important that adequate studies preceded any proposed transplant. The same is probably true in other parts of the range of coho salmon and for other species of Pacific salmon.

The findings of the study are in preparation for submission for publication for the latter half of 1985. Meanwhile, they have been communicated to the Department of Fisheries and Oceans for their implications for management.

Resulting publications

C.F. Wehrhahn and R. Powell. 1985. Electrophoretic variation and population structure in the coho salmon (Oncorhynchus kisutch) of southern British Columbia. Canad. J. Fish. Aquat. Sci. (In press).

Taylor, E.B. and J.D. McPhail. 1985. Burst swimming and size related predation in newly emerged coho salmon (Oncorhynchus kisutch). Trans. Am. Fish. Soc. (Accepted)

Taylor, E.B. and J.D. McPhail. 1985. Ontogeny of the startle response in embryos, alevins and newly emerged coho salmon (Oncorhynchus kisutch). Trans. Am. Fish. Soc. (Accepted)

Taylor, E.B. and J.D. McPhail. 1985. Phenotypic variation among B.C. populations of coho salmon (Oncorhynchus kisutch). I. Morphological variation. (In preparation)

Taylor, E.B. and J.D. McPhail. 1985. Phenotypic variation among B.C. populations of coho salmon (Oncorhynchus kisutch). II. Variation in burst and sustained swimming performance. (In preparation)

Rosenau, M.L. and J.D. McPhail. 1985. A comparison of agonistic behaviour between two populations of juvenile coho salmon (Oncorhynchus kisutch). (In preparation)

Lindsey, C.C. 1985. Experimental study of geographic variation in meristic characters of coho salmon (Abstract). Canadian Congress of Biology, London, Ont. June 1985.

Larkin, P.A. 1985. Managing mixed stocks of coho salmon: genetics, harvesting and enhancement. (In preparation)

Check one/Cocher la case appropriee

- ☐ Biotechnology / Biotechnologie
- ■ Food-Agriculture / Alimentation-Agriculture
- ☐ Communications and Computers / Telecommunications et informatique
- ☐ Industrial Materials and Processes / Materiaux et procedes industriels
- ☐ Energy / Energie
- ☐ Oceans / Ocean
- ☐ Environmental Toxicology / Toxicologie de l'environnement
- ☐ Open / Ouvert

Name/Nom: B.D. McKersie, L.A. Hunt, E. Reinbergs
Department/Departement: Crop Science
University/Universite: University of Guelph
Phone number (optional)/N° de telephone (facultatif): (519) 824-4120 Ext. 3570

Title of Project/Titre du projet: Physiological and Genetic basis of winterhardiness in Triticale and Wheat.

Winter cereals have several advantages compared to spring cereals, including increased grain yield, but their distribution is limited by their winter survival. Physiological and genetic studies were conducted on winterhardiness in winter wheat, triticale and rye with the ultimate objective of developing more winterhardy wheat and triticale varieties.
Overwintering cereals are exposed to a series of environmental stresses but the lethal stress limiting winter survival varies between regions; in Western Canada, cold temperatures limit survival whereas in Eastern Canada, icing and flooding stresses are prevalent. Specifically this project accomplished the following objectives:
a) established the range in genetic variability for freezing, icing and flooding tolerances in wheat and identified lines with superior hardiness for each of these traits. The tolerant plants are being used as a source of stress tolerance in the ongoing wheat and triticale plant breeding programs at Guelph, and are available to other plant breeders. A Canadian winterhardiness nursery was established and distributed to plant breeders in Alberta, Saskatchewan, Ontario, Prince Edward Island, and New York state for evaluation. It is intended that this nursery will provide for an evaluation of elite winterhardy material and facilitate the exchange of genetic material across Canada.
b) examined anaerobic metabolism of flooded and iced cereal seedlings with the objective of determining what metabolic lesion was developed during the stress, or in other words, to determine why the plant died, and what metabolic mechanisms of tolerance existed in the hardy wheat and rye cultivars. The data indicated that tolerance was not due to altered rates of respiration, to reduced levels of "toxic" anaerobic end products, or to a loss of carbohydrate reserves. Instead, the more tolerant cereals would withstand a state of low energy, rather than maintain a high energy charge under anaerobic conditions.
c) examined freezing stress, with a similar objective to (b). At the whole plant level, freezing tolerance was dependent on the survival of a small group of cells at the base of the crown in all lines of wheat, rye and triticale examined. At the subcellular level, lethal freezing induced a reorganization of the packing of membrane phospholipids. The mechanism leading to this reorganization involves the deesterification of some phospholipids, and production of free fatty acids. These results offer an explanation for the common observation that freezing injury involves a loss of osmotic responsiveness and leakage of cytoplasmic metabolites.
d) examined the environmental impact on the acclimation of different genotypes and the expression of hardiness traits. Plants which have a high degree of stress tolerance in one region, do not necessarily express that hardiness in other regions. For example, Fredrick is considered a moderately hardy wheat, and Norstar very hardy in the dry climate of western Canada. On some sites (or years) in southern Ontario, their hardiness is equivalent and in others Fredrick is superior. This has implications in the selection of parents carrying these traits in the breeding program.
e) examined the feasibility of using triticale as vehicle to transfer hardiness from the agronomically poor rye (low yield, low feed quality) to an agronomically superior cereal, wheat or triticale. The results were disappointing because the hardiness of triticale was dependent on the hardiness of the wheat parent and independent of the the hardiness of the rye parent. More sophisticated screening and evaluation than presently used is required to facilitate this method of transfer. However, because of the limited variability for some of the traits associated with winterhardiness in wheat, emphasis should be placed on improving the methodology.

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FIELD OF RESEARCH / DOMAINE DE RECHERCHE
(Check one/cocher la case appropriée)

- ☐ Biotechnology / Biotechnologie
- ■ Food-Agriculture / Alimentation-Agriculture
- ☐ Communications and Computers / Telecommunications et informatique
- ☐ Industrial Materials and Processes / Materiaux et procedes industriels
- ☐ Energy / Energie
- ☐ Oceans / Oceans
- ☐ Environmental Toxicology / Toxicologie de l'environnement
- ☐ Open / Ouvert

Name/Nom: Edward McKyes
Department/Département: Agricultural Engineering
University/Université: McGill University
Phone number (optional)/N° de téléphone (facultatif): (514) 457-2000, ext. 164

Title of Project/Titre du projet: ENERGY CONSERVATION IN CORN PRODUCTION

For many years there has been a controversy as to whether reduced and zero tillage crop production systems are appropriate for the humid and cool Eastern Ontario and Western Quebec climates. Fears have been expressed that the cool temperatures and high rainfall, compared to the Mid-western United States, would lead to excessive soil compaction, loss in soil water storage and aeration and sharply reduced crop yields, possibly aggravated by high weed growth, if reduced or zero tillage were attempted on a commercial scale in this region. The objective of this study was to verify if these fears were true by setting up field scale trials of reduced and no-tillage cultural systems for the production of silage corn feed, using actual full scale agricultural machinery and common practices of fertilization and weed control. The demonstration was backed up by extensive scientific measurements of soil conditions in the reduced tillage fields of clay and sand soils, and comparitive conventionally moldboard plowed fields, as well as of water movement, organic matter contents, fertlity levels and the quality of feed produced in the different tillage systems. In addition, the use of dairy cow manure to replace manufactured nitrate-phosphate fertilizers was tried on the different fields and compared with the conventional inorganic fertilizer applications.

The results of the study, carried out for three consecutive years on the same fields, demonstrated that reduced and zero-tillage cultural systems are indeed viable alternates to be considered for Eastern Canadian agricultural opertaions. On the average, there was no significant reduction in crop yields or quality in the reduced or zero tillage fields, compared to conventionally prepared plots. There was slight compaction of the topsoil in the zero-tillage fields of sand and clay, but not enough to affect crop performance.

Three cautions are to be recommended if reduced or zero-tillage systems are contemplated in this region:

1. The size of machinery should be kept relatively small, in general less than 5 tonnes mass. If this is not doen, excessive and unrelieved soil compaction will probably result in a loss of soil physical quality, and of crop yields, especially in a zero tillage system.
2. Attention must be paid to the control of weed populations throughout the season. Although no special problems were encountered in these tests with weeds, and normal applications of herbicides were applied to conventional and reduced tillage systems alike, an area where there are severe and persistent weed problems might result in excessive weed growth, and a consequent loss in crop yields.
3. Care must be taken on pure sand soils with the application of manure as fertilizer under a no-tillage scheme. The lack of mixing of manure with the soil, and the small absorbance of acids by a sand, can result in the killing of most crop shoots before they can emerge from the ground, and yields will necessarily be diminished.

PUBLICATIONS RESULTING FROM THE STUDY:

Kelly, J.K., McKyes, E., Owen, G., MacKenzie, A.F. and Watson, A.K. Tillage and fertilizer effects on silage corn production. ASAE Paper No.84-1543 (printed). New Orleans, 1984.

Kelly, J.K. and McKyes, E. The influence of tillage, zero-tillage and fertilizer sources on corn growth and yield. Submitted to Transactions ASAE, 1985.

Kelly, J.K. and McKyes, E. The effects of tillage, zero tillage and fertilizer sources on soil structure, nutrient and moisture distribution in silage corn production. Submitted to Soil & Tillage Research Journal, 1985.

Kelly, J.K. and McKyes, E. The influence of tillage, zero-tillage and fertilizer sources on soil structure and growth of silage corn in Eastern Canada. Paper to be presented at the 10th International Conference of the Soil Tillage Res. Org., Guelph, ON, 1985.

FIELD OF RESEARCH / DOMAINE DE RECHERCHE
(Check one/cocher la case appropriee)

- ☐ Biotechnology / Biotechnologie
- ■ Food-Agriculture / Alimentation-Agriculture
- ☐ Communications and Computers / Telecommunications et informatique
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- ☐ Energy / Energie
- ☐ Oceans / Oceans
- ☐ Environmental Toxicology / Toxicologie de l'environnement
- ☐ Open / Ouvert

Name/Nom: Jeremy N. McNEIL
Department/Département: Biologie
University/Université: Laval
Phone number (optional)/N° de telephone (facultatif): (418) 656-2999
Title of Project/Titre du projet: Role of pheromones in Pseudaletia unipuncta population dynamics and its importance in management programmes of this and other noctuid species.

Studies on the pheromone mediated mating system of Pseudaletia unipuncta found that both biotic (density, nutrition) and abiotic (temperature, photoperiod) factors markedly affect different aspects of female calling behaviour, male receptiveness to the female sex pheromone and the production of the male pheromone in the hairpencils. In general fall conditions result in a pronounced delay in female calling and male responsiveness, so that very few mated individuals are found during the late summer flight in Quebec. It was initially hypothesised that the sporadic epidemics of this pest were related to the fall mating success in local populations, however subsequent work has clearly demonstrated that this species is unable to overwinter successfully in the northern part of its geographic distribution. While this hypothesis is still considered valid for more southerly habitats where the armyworm can overwinter, the observed changes in the northerly populations are believed to be related to a migratory capacity. In the past it has generally been accepted that species such as the armyworm, are carried north in the summer and that these populations become extinct at the onset of winter. The data accumulated suggest that the armyworm, and possibly several other pestiferous Noctuid species, have the physiological capacity to migrate to suitable overwintering sites in the fall. This hypothesis is presently under investigation for a better understanding of the movement would provide a more sound basis for a management programme.

Fields, P.G. and J.N. McNeil. 1984. The overwintering potential of the armyworm, Pseudaletia unipuncta (Lepidoptera: Noctuidae), populations in Quebec, Can. Ent. 116: 1647-52.

Fitzpatrick, S.M., D. Miller, I. Weatherston and J.N. McNeil. Determining pheromone content of hairpencils from individual virgin males of Pseudaletia unipuncta (Haw.) (Lepidoptera: Noctuidae). J. Chem. Ecol. (In press).

Delisle, J. and J.N. McNeil. The effect of photoperiod on the calling behaviour of the armyworm, Pseudaletia unipuncta (Haw.)(Lepidoptera: Noctuidae). Submitted to J. Insect Physiol.

McNeil, J. N. 1985. The true armyworm, Pseudaletia unipuncta (Haworth) (Lepidoptera:Noctuidae) A possible migrant species. Proceedings of the symposium Movement and dispersal of biotic agents (in press).

_____, Differences in the efficacy of sex-pheromone and light traps in the seasonal monitoring of the true armyworm, Pseudaletia unipuncta (Haw.) (Lepidoptera: Noctuidae) and the implications concerning migration of this species. Submitted to Env. Ent.

McNeil, J.N. and J.J. Turgeon. 1982. Pheromone biology in the population dynamics of Pseudaletia unipuncta (Haw. (Lepidoptera: Noctuidae), a sporadic pest. pp 217-24 in Les médiateurs chimiques agissant sur le comportement des insectes. Les colloques d'INRA, # 7.

Turgeon, J.J. and J.N. McNeil, 1983. Modifications in the calling behaviour of Pseudaletia unipuncta (Haw.) (Lepidoptera:Noctuidae), induced by temperature during pupal and adult development. Can. Ent. 115: 1015-22.

_____, Effect of larval food on the calling behavior of virgin females of the true armyworm, Pseudaletia unipuncta (Haw.). Submitted to Can. Ent.

Turgeon, J.J., J.N. McNeil and W.L. Roelofs. 1983. Responsiveness of Pseudaletia unipuncta males to the female sex pheromone. Physiol. Ent. 8: 339-44.

_____, 1983. Evaluation of sex pheromone traps for the armyworm, Pseudaletia unipuncta (Haw.) (Lepidoptera: Noctuidae) Env. Ent. 12: 891-4.

FIELD OF RESEARCH / DOMAINE DE RECHERCHE
(Check one/cocher la case appropriee)

- ☐ Biotechnology / Biotechnologie
- ■ Food-Agriculture / Alimentation-Agriculture
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- ☐ Energy / Energie
- ☐ Oceans / Oceans
- ☐ Environmental Toxicology / Toxicologie de l'environnement
- ☐ Open / Ouvert

Name/Nom: Bruce D. Murphy
Department/Département: Biology
University/Université: University of Saskatchewan
Phone number (optional)/N° de téléphone (facultatif): (306) 966-4411
Title of Project/Titre du projet:

STUDIES OF EQUINE CHORIONIC GONADOTROPHIN

SUMMARY

The purpose of the recently completed study was to determine the variability in a placental hormone produced between days 50 and 130 of gestation in the mare. This hormone, known as equine chorionic gonadotrophin is important because it can be purified from the serum of mares and used to induce ovarian function in sheep, pigs and cattle. It has unique dual biological activity and its particular value lies in its capability to stimulate superovulation in cattle. It is, therefore, useful to the embryo transfer industry. Equine chorionic gonadotrophin is not widely used at this time because of the variable ovarian responses which result from its application to cattle.

In our study of eCG we were able to use an unprecedented number of mares on the Bar-C Ranch, Rossburn, Manitoba. We therefore studied 222 pregnancies resulting from the breeding of 187 mares to 11 different stallions over three years. A second trial was carried out using 90 standardbred mares each bred to one of four stallions from Gunnholme Farms, Lloydminster, Saskatchewan. In both components of the study, blood samples were taken weekly between days 50 - 100 of gestation and analyzed for total eCG activity by radioimmunoassay. The biological activity of the eCG collected from 40 pregnancies was determined by bioassay. The results of statistical analysis revealed that the amount of eCG produced during a pregnancy was related to the sire to which the mare was bred and to the age of the mare. Further, the biological activity of the hormone was in part attributable to the stallion to which the mare was bred. These results are highly significant to the industry which produces eCG and to the primary users of eCG, animal breeders. The data demonstrate that it is possible to modify the eCG concentrations and biological activity by selecting mares and sires. By means of this selection, it may be possible to produce more and better eCG for use in the animal industry.

FIELD OF RESEARCH / DOMAINE DE RECHERCHE
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☐ Biotechnology / Biotechnologie	☐ Communications and Computers / Telecommunications et informatique	☐ Energy / Energie	☐ Environmental Toxicology / Toxicologie de l'environnement
■ Food-Agriculture / Alimentation-Agriculture	☐ Industrial Materials and Processes / Materiaux et procedes industriels	☐ Oceans / Oceans	☐ Open / Ouvert

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Title of Project/Titre du projet: Statistical optimization of food research

Simplex optimization can substantially improve research efficiency; for example, 37 experiments were required to achieve optimal analytical conditions compared to 168 experiments without using optimization methodology (Betteridge et al. 1983). However, during simplex optimization, an iterative (sequential) search, the response surface is invisible. To expedite the search, an attempt was made to visualize the response surface. An approximation was made for graphing higher orders than three dimensions by dividing the level values of each factor into four groups of equal intervals, and then the plotted response values were linked to each other when all other factor levels were within the interval of same groups. In conjunction with a subsequent simultaneous shift process of factor level values, this new **mapping simplex optimization** significantly improved the optimization efficiency (Nakai et al., 1984). However, the process subsequent to mapping required manual adjustments. An attempt was made to standardize the optimization procedure to avoid subjectivity. The new, standardized optimization reached the optimum after average 38.3 experiments compared to 86.7 experiments when the currently most popular simplex optimization was used. A self-instructive computer program of the standardized procedure was written for hand-held computers for easier application of optimization, as these low-cost computers were transferable to any locations (Nakai, 1985).

In conventional simplex optimization, the conditions of each subsequent experiment are computed to be reflection, expansion, or contraction of the current simplex (a group of n+1 experiments; n is the number of factors), one of them replaces the worst conditions of the previous simplex, thus maintaining the number of experiments within simplex constant. It was found that experimenting at the centroid conditions, that has not been used for experimenting, improved the efficiency in searching for the optimum if the search range was restricted. To supplement a limited capacity of this centroid method in search over a wide area, a process for changing search range was incorporated into the computer program. This new **centroid mapping optimization** was more efficient than other simplex methods (Aishima and Nakai, 1985). Programming for microcomputers with CRT screens for more flexible optimization is underway.

Advantages of these new optimization techniques developed by support of this grant are:

1. The techniques are applicable to any projects in analysis, research and development without requiring pre-set working equations.
2. The new methods are more efficient than other simplex optimization techniques that are already proved to be more flexible than the conventional response surface methodology (RSM) and Fletcher-Powell method (FPM), which are not effective when the search is far from the optimum.
3. Time for labour, for instrument operation and of supervisory personnel as well as the costs of reagents and supply can be significantly reduced.

Statistical optimization has become more popular recently in food research as shown in Saguy's publications (a book, 1983, and a review, 1984). This trend may be accelerated for increasing competition in the food industry. We intend to develop the most efficient optimization technique for food research, to write a comprehensive, self-instructive computer program for low-cost portable computers, and finally to develop an automated research administration plan that is composed of: 1. feasibility survey by specially designed computer databases, 2. literature survey by computerized search systems, 3. fractional factorial analysis for selecting influential factors, 4. optimization using the selected factors, and 5. final decision making.

Publications

Nakai, S., Koide, K., and Eugster, K. 1984. A new mapping super simplex optimization for food product and process development. J. Food Sci. 49:1143-48 &70.

Nakai, S. 1985. Standardization of mapping simplex optimization. J. Food Sci. 50: in press.

Aishima, T. and Nakai, S. 1985. Centroid mapping optimization: a new efficient optimization for food research and processing. Abstract submitted for presenting a paper at the 45th Annual Meeting of Institute of Food Technologists. Atlanta in June.

SUMMARY OF COMPLETED RESEARCH PROJECT / RÉSUMÉ DU PROJET DE RECHERCHE TERMINÉ

Strategic Field / Domaine thématique: FOOD/AGRICULTURE

Name of Grantee / Nom du bénéficiaire: S.C. NEGI AND J.C. JOFRIET

Department and University / Département et université: SCHOOL OF ENGINEERING, UNIV. OF GUELPH

Phone Number (optional) / N° de téléphone (facultatif): (519) 824-4120 Ext. 2231

Title of Project / Titre du projet: STRUCTURAL DESIGN LOADS FOR FARM TOWER SILOS

The feasibility of ensiling corn at low dry matter percentages in Canada, as a means of extending the northern limit of this crop, is dependent to a great extent on the availability of proper storage facilities for the preservation of the stored material. This project was concerned with the design of such storage structures for a wide range of crops and filling conditions. The study was carried out in three phases. During the first phase the background data on the engineering aspects of ensiling crops were compiled. This included a review of the design loading standards around the world. In the second phase the engineering design criteria for farm tower silos were developed. Formulas and graphs based on available data in the literature were prepared to cover different types of silos and silages. A new method was put forward to account for the effective fiber pressures developed by a saturated silage mass. The design considerations included the location of saturation depths, the computation of lateral wall pressures and the determination of average bulk density in a tower silo. In the third and final phase of this study a rational procedure was formulated for estimating the pressures exerted by low and high-moisture silages in top and bottom-unloading silos. Design examples were prepared for each case illustrating the step-by-step approach to calculation of lateral wall pressures.

Resulting Publications:

Jofriet, J.C. and S.C. Negi. 1984. Farm silo design in Canada. Proc. 1st European Symp. Stress & Strain Behaviour of Particulate Solids, Prague, Czechoslovakia. 10 pp.

Negi, S.C. and J.C. Jofriet. 1984. Lateral pressures in farm tower silos. Trans. Amer. Soc. Agric. Eng. 27(2):487-490.

(Check one/cocher la case appropriée)

- ☐ Biotechnology / Biotechnologie
- ■ Food-Agriculture / Alimentation-Agriculture
- ☐ Communications and Computers / Telecommunications et informatique
- ☐ Industrial Materials and Processes / Matériaux et procédés industriels
- ☐ Energy / Énergie
- ☐ Oceans / Océans
- ☐ Environmental Toxicology / Toxicologie de l'environnement
- ☐ Open / Ouvert

Name/Nom: Dr. R. E. Peter
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University/Université: Alberta
Phone number (optional)/N° de téléphone (facultatif): [403] 432-3464

Title of Project/Titre du projet: **Induced spawning of fish by LRH-A**

Cultured fish are held in high densities in ponds and usually do not reproduce naturally. Therefore, to produce fish fry, ovulation must be induced artificially when the females are mature, and then the ovulated eggs stripped from the females and fertilized. The purpose of this research was to determine the conditions under which the synthetic analogue of the neurohormone, [D-Ala^{6}, Pro^{9}-NEt]-luteinizing hormone-releasing hormone (LRH-A) which stimulates secretion of the pituitary hormone gonadotropin, can be injected into goldfish to cause ovulation. The results of these studies should be applicable to cultured fish, particularly the various species of carp.

The finding, from other research in my laboratory, that the brain substance dopamine acts as an inhibitory neurohormone on gonadotropin secretion greatly aided the present research. It was found that injection of LRH-A alone was relatively ineffective for inducing ovulation in goldfish. However, when the inhibitory neurohormone was blocked by injection of the drug pimozide, the actions of LRH-A were greatly increased. Injection of pimozide and LRH-A together proved to be a highly effective means of stimulating ovulation in goldfish. Furthermore, this combination is also effective with common carp. The benefit of this new technique for stimulating ovulation and spawning of cultured fish is that it promises to be more cost effective in terms of labor and materials than procedures now used.

Publications:

Chang, J.P., and Peter, R.E. (1983a). Effects of dopamine on gonadotropin release in female goldfish, Carassius auratus. Neuroendocrinology 26:351-357.

Chang, J.P., and Peter, R.E. (1983b). Effects of pimozide and Des Gly^{10}, [D-Ala^{6}] luteinizing hormone-releasing hormone ethylamide on serum gonadotropin concentrations, germinal vesicle migration and ovulation in female goldfish, Carassius auratus. Gen. Comp. Endocrinol. 52: 30-37.

Chang, J.P., Peter, R.E., Nahorniak, C.S., and Sokolowska, M. (1984). Effects of catecholaminergic agonists and antagonists on serum gonadotropin concentrations and ovulation in goldfish: Evidence for specificity of dopamine inhibition of gonadotropin secretion. Gen. Comp. Endocrinol. 55:351-360.

Peter, R.E. (1982). Nature, localization and actions of neurohormones regulating gonadotropin secretion in teleosts. In "Reproductive Physiology of Fish" edited by C.J.J. Richter and H.J.Th. Goos. Pudoc, Wageningen, Netherlands. pp. 30-39.

Sokolowska, M., Peter, R.E., Pan, C.H., Nahorniak, C.S., and Chang, J.P. (1982). Effects of pimozide and des-Gly^{10}[D-Ala^{6}] LH-RH ethylamide (LRH-A) on gonadotropin release and ovulation in goldfish. Amer. Zool. 22:947 (Abstract #535).

Sokolowska, M., Peter, R.E., Nahorniak, C.S., Pan, C.H., Chang, J.P., Crim, L.W., and Weil, C. (1984). Induction of ovulation in goldfish, Carassius auratus, by pimozide and analogues of LH-RH. Aquaculture 36:71-83.

Sokolowska, M., Peter, R.E., Nahorniak, C.S., Chang, J.P. (1985a). Seasonal effects of pimozide and des Gly^{10}[D-Ala^{6}] LHRH ethylamide on gonadotropin secretion in goldfish. Gen. Comp. Endocrinol. (in press).

Sokolowska, M., Peter, R.E., and Nahorniak, C.S. (1985b). The effects of different doses of pimozide and [D-Ala^{6}, Pro^{9}-N ethylamide]-LHRH (LHRH-A) on gonadotropin release and ovulation in female goldfish. Can. J. Zool. (accepted for publication, subject to minor revision).

FIELD OF RESEARCH / DOMAINE DE RECHERCHE
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☐ Biotechnology / Biotechnologie
■ Food-Agriculture / Alimentation-Agriculture
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☐ Industrial Materials and Processes / Materiaux et procedes industriels
☐ Energy / Energie
☐ Oceans / Oceans
☐ Environmental Technology / Technologie de l'environnement
☐ Open / Ouvert

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Title of Project/Titre du projet

The Elimination of Trans Isomers in Hydrogenated Oils

Natural sources of edible oils and fats contain almost exclusively the cis isomers of unsaturated fatty acids. When these natural oils are partially hydrogenated, in order to improve their stability and to alter physical characteristics, the remaining unsaturated fatty acids contain significant concentrations of trans isomers. Although the evidence is not conclusive, there has been increasing concern that trans isomers, or some specific trans isomer, may contribute to cardiovascular disease, or may interfere with the uptake of essential fatty acids. Since partially hydrogenated edible oils are essential ingredients in a great variety of products such as margarine, shortenings, mayonnaise, salad dressings, etc., it seems prudent to develop processes that could lead to a reduction of trans fatty acids in the diet.

During the past three years a wide range of catalysts have been studied, both those that form a suspension in the oil, like conventional nickel catalysts (heterogeneous) as well as those soluble in oil (homogenous). Heterogeneous catalysts gave high trans-isomer contents. The work established that, contrary to claims in the patent literature, gold does not give low-trans products. Gold did have unusual catalytic properties that may make it useable in the stabilization of highly unsaturated oils.

Two homogeneous catalysts show promise. We have carefully studied the mechanism of action of a known chromium complex, since it may be used as a model for the action of other homogeneous catalysts.

We have also discovered that it combines readily with the active sites of the heterogeneous nickel catalyst giving combinations that may have the best virtues of both components. The mixed catalyst systems offer very interesting possibilities, both theoretical and practical. This will be explored under our current strategic grant.

We have found a complex ruthenium compound that is an active homogeneous catalyst for the hydrogenation of edible oils. It is, in fact, very active at extremely low concentrations. The amount of trans isomers produced was found to vary significantly with pressure. It was possible to reduce trans isomer content to approximately one tenth of the values normally expected with heterogeneous nickel catalysts. Much further study is needed to determine the mechanism of action of this very promising catalyst and to find ways of immobilizing it on a solid support so that it can be readily removed from the oil.

In addition to further work on the ruthenium complex, we plan to carry on with a survey of promising homogeneous catalysts. We have synthesized some ourselves and others have been described in the literature, but usually in connection with the hydrogenation of unsaturated hydrocarbons of interest to the petroleum industry. Much stress will be put on the attachment of homogeneous catalysts to solid supports, either inert materials or the surface of heterogeneous catalysts. Finally, we plan to use our best catalyst system to prepare ingredients which can be used in the manufacture of edible oil products.

FIELD OF RESEARCH / DOMAINE DE RECHERCHE
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- ☐ Communications and Computers / Telecommunications et informatique
- ☐ Industrial Materials and Processes / Materiaux et procedes industriels
- ☐ Energy / Energie
- ☐ Oceans / Oceans
- ☐ Environmental Toxicology / Toxicologie de l'environnement
- ☐ Open / Ouvert

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Title of Project/Titre du projet: Effectiveness and utilization of different sources and types of fibre in dairy cattle rations

This project was designed to investigate the influence of particle length on forage utilization and animal production. The first area investigated was the measurement and description of forage length. Forage samples represent a distribution of particle lengths. A weighted mean particle length measure along with a coefficient of spread was developed. The weighted mean particle length is that length at which 50% of the cumulative weight is obtained. The coefficient of spread is an indication of the distribution of the lengths.

As ingestion and rumination play a major role in forage utilization, it was felt that information on these parameters might help explain the varied responses of animals to forages of different qualities. A chewing monitor was developed that allows the differentiation of eating, ruminating, drinking, bawling and the number of chews per bolus, as chewing is the main method of particle size reduction and particle size also influences the removal rate from the rumen.

In the animal trials with lactating dairy cows and cannulated steers, the influence of forage particle length on animal performance and utilization was studied. Results indicate that particle length alone can influence milk fat production with no influence on milk yield or feed intake. When forage particle length was studied with varying levels of concentrate, it was found that at lower levels of concentrate intake the two lengths studied had an effect on milk fat %. At higher levels of concentrate intake, there was no significant effect of forage particle length on milk fat production. The chewing parameters measured reflected the milk fat responses. The trials underway with the cannulated animals will look in detail at sites of digestion, VFA ratios, rumen turnover time and fibre digestion. Processing influences the distribution of particle lengths and also alters the distribution of nutrients. Forage species and maturities also respond differently to processing.

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- A.S. Vaage and J.A. Shelford. 1984. Non-sieving linear evaluation of chopped forage. Can.J.Anim.Sci. (December). Abstract.
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- A.S. Vaage and J.A. Shelford. 1984. Precision and accuracy of a simple vibrating tray forage particle separator, p. 169. In Techniques in particle size analysis of feed and digesta in ruminants. Ed. P.M. Kennedy. Occasional Publication #1,Canadian Society of Animal Science.
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☐ Energy / Energie
☐ Oceans / Océans
☐ Environmental Toxicology / Toxicologie de l'environnement
☐ Open / Ouvert

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Title of Project/Titre du projet: Selection of drought resistant cereals by hormone analysis

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Selection of drought resistant cereals by hormone analysis.

An analytical technique has been developed that uses a combination of high-pressure liquid chromatography and radioimmunoassay to detect the hormone abscisic acid in a single wheat plant. Abscisic acid is the principal hormone produced in many crop plants, including wheat, following exposure to drought stress. Using the technique the possibility that abscisic acid levels could provide selection indexes for drought resistance in wheat was tested on plants grown in field conditions. Significant genetic differences were found among cultivars in the levels of abscisic acid produced when wheat plants were drought-stressed. However these abscisic acid levels were poorly correlated with the levels of reduction in grain yield caused by the drought stress. A low reduction in grain yield following drought stress is a primary goal of wheat breeders aiming to improve drought resistance in wheat. The conclusion is that analysis of the hormone abscisic acid cannot provide a useful selection index for improving drought resistance in wheat.

T. Kannangara, G.M. Simpson, K. Rajkumar & B.D. Murphy. 1984. Analysis of abscisic acid in wheat leaves by a combination of high-performance liquid chromatography and radio-immunoassay. J. Chromatography 283: 425-430.

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- [ ] Communications and Computers / Telecommunications et informatique
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- [ ] Energy / Energie
- [ ] Oceans / Oceans
- [ ] Environmental Toxicology / Toxicologie de l'environnement
- [ ] Open / Ouvert

Name/Nom: St-Pierre, S.A.
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University/Université: Sherbrooke
Phone number (optional)/N° de telephone (facultatif):
Title of Project/Titre du projet: Entérotoxines de Escherichia coli d'origine animale

Les colibacilloses représentent une fraction importante des causes de diarrhée néonatale, autant chez l'homme que chez l'animal domestique. Elles sont une importante cause de décès d'enfants nouveaux-nés à travers le monde, surtout dans les pays sous-développés. Elles gâchent chaque année les vacances de centaines de touristes, d'où sa désignation sous le nom espagnol de ''turista''. Enfin, sur le plan économique, elles sont directement responsables de pertes annuelles de plusieurs centaines de millions de dollars par les éleveurs de bétail du monde entier, en causant, comme chez l'humain, la mort par déshydratation rapide d'une fraction importante de la production de veaux et de procelets.

Quoique les souches connues de Escherichia coli soient nombreuses, différant entre elles surtout de par la nature de leurs glycoprotéines membranaires qui servent de facteurs d'attachement à la muqueuse intestinale de la victime, elles ont en commun des produits de sécrétion, ou entérotoxines, dont la nature peptidique est maintenant confirmée. Toutes les souches entérotoxigéniques connues de E. coli produisent une toxine thermostable de moins de vingt acides aminés, contenant trois ponts disulfure, connue sous l'abréviation de ST ou STa. Une deuxième catégorie de toxines thermostables, abréviée ST' ou STb, n'a été caractérisée jusqu'à maintenant qu'à partir de la séquence du nucléotide correspondant et contient 42 acides aminés et deux ponts disulfures. Enfin, une troisième catégorie d'entérotoxines apparentée à la toxine du choléra, thermolabile et de masse moléculaire élevée, est également produite par la plupart des souches pathogènes de E. coli.

Le projet pour lequel nous avons reçu un support financier de trois ans du CRSNG, sous la forme d'une subvention thématique, visait trois objectifs principaux. Le premier consistait à tenter de caractériser chimiquement la séquence de STa et déterminer l'emplacement des trois ponts disulfures stabilisant la molécule. Le second était de mettre au point une méthode efficace de préparation pour obtenir des quantités de l'ordre du gramme de toxine synthétique destinée à l'immunisation expérimentale et à la préparation d'anticorps pour utilisation diagnostique. Enfin, le troisième objectif du projet visait à développer une méthode de caractérisation rapide de la colibacillose chez l'humain ou l'animal basée sur l'identification immunologique de STa, au moyen d'un ELISA ou d'un RIA utilisant des anticorps qui reconnaissent ce produit de sécrétion.

Ces trois objectifs ont été atteints pendant la période de financement du projet. STa isolée de la souche F11(P155) d'origine porcine a été identifiée comme étant un octadécapeptide tricyclique de séquence H-Asn-Thr-Phe-Tyr-Cys-Cys-Gly-Leu-Cys-Cys-Asn-Pro-Ala-Cys-Ala-Gly-Cys-Tyr-OH. Le peptide a été synthétisé par la technique de phase solide et son activité biologique correspondait exactement à celle de STa d'origine bactérienne. Enfin, des anticorps spécifiques à STa, capables de neutraliser l'action biologique de l'entérotoxine chez la souris, ont été obtenus par immunisation de lapins à l'aide de la toxine synthétique couplée de façon covalente à de l'albumine de serum bovin. Un test ELISA capable de détecter des concentrations picomolaires de STa a été mis au point. Ce test serait applicable commercialement au diagnostic de la colibacillose chez l'humain aussi bien que chez l'animal.

FIELD OF RESEARCH / DOMAINE DE RECHERCHE
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- ☐ Agriculture / [illegible]-Agriculture
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- ☐ Oceans / Oceans
- ☐ Open / Ouvert

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University/Universite: Guelph
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Title of Project/Titre du projet: Increasing the yield of edible protein through dietary means

An animal industry today can only be justified on the basis of providing high quality protein for the human population at economical cost. Hence, it is important that feeding programs today be evaluated in terms of optimizing edible protein yield rather than optimizing weight gain and gain:feed ratio as they have in the past.

The aim of the present study was to investigate edible meat yield from broilers and turkeys by altering diet composition.

An experiment with chicken broilers demonstrated that, although edible meat (including skin and fat), remained relatively constant, as a percent of live weight with increased dietary protein levels, the yield of edible carcass protein was increased.

A comparison of the chicken and turkey demonstrated that edible carcass protein could be enhanced with dietary protein and/or amino acid levels that were in excess of those required to maximum gain. The study also demonstrated the superiority of the turkey with respect to edible protein yield, as a percent of dietary protein consumed as compared to the broiler.

A study with turkeys and broilers, where various levels of essential and non essential amino acids were used to supplement diets, suggests that the turkey may respond to amino acid supplemented diets in a different manner than does the chicken broiler. It is obvious that edible carcass protein levels can be altered in both the turkey and broiler by changing the levels of dietary essential amino acid supplementation, as well as altering the ratio of essential to non essential nitrogen.

What is now required are studies to generate a new set of essential amino acid values that optimize edible carcass protein yield, rather than weight gain and gain:feed ratio.

A one percent improvement in the yield of meat from poultry carcasses could be worth 12 to 15 million dollars to the Canadian Poultry Industry.

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3. Summers, J.D., S. Leeson and Huile Shen, 1984. Efficiency of turkeys versus broilers in the utilization of dietary protein. Poultry Sci. (submitted).

4. Bedford, M.R. and J.D. Summers, 1984. Effect of altering the source of non essential nitrogen on performance and carcass composition of the broiler chick. British Poultry Sci. (accepted).

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- ☐ Biotechnology / Biotechnologie
- ☐ Communications and Computers / Telecommunications et informatique
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- ■ Food-Agriculture / Alimentation-Agriculture
- ☐ Industrial Materials and Processes / Materiaux et procedes industriels
- ☐ Oceans / Oceans
- ☐ Open / Ouvert

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Title of Project/Titre du projet: Integrated disease management for improved productivity of winter wheat.

The aim of this research was to develop improved practices for managing diseases and optimizing productivity in winter wheat. This crop is important economically and because it improves the structure and reduces erosion of the soil. Diseases affecting the leaves, heads, crowns and lower stems were examined in relation to weather factors, soil conditions, crop management practices and crop productivity. Effects of weather factors (eg. temperature, leaf wetness) on rates of increase of foliar diseases were studied throughout the growing season. These data enable us to predict outbreaks of certain diseases and to adjust disease management practices accordingly. Management practices examined in relation to disease and yield included fungicides and growth regulator applications, nitrogen treatments, time of sowing, seeding rates, cultivar and biological control. The fungicide work focussed on using minimal doses applied at critical times to optimize disease management and obtain the best economic yields. Several systemic fungicides applied only once at extremely low doses (one cupful per hectare) shortly after the wheat heads emerged controlled disease outbreaks and improved yields by 12 to 35% in most studies. Fungicides applied earlier in the spring gave lower yield increases (6-12%) while those applied in the fall gave little or no yield improvement. Yield responses depended on cultivar, moisture, nitrogen levels and use of a growth regulator. Several fungicides reduced incidence of head blight, a disease associated with mycotoxins in wheat grain. Lower seeding rates and delayed sowing dates were excellent disease management practices which improved yields. In diagnostic surveys, fungi causing diseases of the crown and lower stem, and races of the fungus which causes powdery mildew were identified. Seed treatments were evaluated for managing crown rot. The race surveys are important for resistance breeding. Integration of the new practices for disease control into winter wheat management will contribute to higher economic yields, better disease control, reduced risks of mycotoxins and increased economic competitiveness of the crop.

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STRATEGIC FIELD: INDUSTRIAL MATERIALS AND PROCESSES

DOMAINE THÉMATIQUE: MATÉRIAUX ET PROCÉDÉS INDUSTRIELS

INDUSTRIAL MATERIALS AND PROCESSES

Strategic Grants in Industrial Materials and Processes are intended to encourage research in innovative processes, materials and technology and the means for achieving their application to efficient industrial-scale production.

The following list includes areas in which proposals will be considered. The list is by no means exhaustive.

Materials

Materials encompasses the development of new substances of industrial importance, the characterization of their properties and the investigation of their behavior in industrial applications. Innovative uses of existing materials are also included.

Examples of materials are:

- Cellulosics
- Polymers
- Ceramics
- Composites
- Metals and Alloys
- Coatings
- Construction Materials
- Semiconductors

Manufacturing Processes

The exploitation of natural resources to produce raw materials, or the transformation of raw materials to intermediates or finished products generally involves a sequence of processing steps, which result in a more valuable product. Examples of such processes are:

- Chemical and catalytic processes: conversion of hydrocarbon- and coal-based feedstocks, hydrogenation (C_1 chemistry) processes, processing for foreign-atom removal (S and N), polymerization processes, etc.
- Raw material extraction: grinding, benefication, agglomeration, etc.
- Metallurgy: refining, casting, joining, alloy and property development, coating, corrosion protection, etc.
- Production of ceramics: glasses, refractories, cements, etc.
- Production of industrial gases
- By-product and/or waste utilization
- Forest product (pulp and paper) processes
- Manufacture of semiconductor materials
- Fabrication of new construction materials

MATÉRIAUX ET PROCÉDÉS INDUSTRIELS

Les subventions thématiques dans le domaine des matériaux et procédés industriels visent à encourager la recherche dans les procédés, les matériaux et les technologies innovatrices et à assurer les moyens de parvenir à appliquer les résultats de cette recherche à une production efficace à l'échelle industrielle.

Voici une liste, qui n'est nullement exhaustive, des domaines dans lesquels on attend des propositions.

Matériaux

Ce domaine comprend le développement de nouvelles substances d'importance industrielle, la caractérisation de leurs propriétés et l'étude de leur comportement dans des applications industrielles, ainsi que la mise au point d'utilisations innovatrices de matériaux déjà existants.

Voici des exemples de matériaux:

- Produits cellulosiques
- Polymères
- Céramiques
- Composites
- Métaux et alliages
- Revêtements
- Matériaux de construction
- Semi-conducteurs

Procédés

L'exploitation des ressources naturelles pour la production des matières premières, ou la transformation de matières brutes en produits intermédiaires ou finis fait intervenir en général une suite d'étapes de traitement dont le résultat est un produit amélioré. Voici des exemples de ces procédés.

- Procédés chimiques et catalytiques: conversion des charges de départ à base d'hydrocarbures et de charbon, procédés d'hydrogénation (chimie du C_1), traitement pour éliminer les hétéroatomes (S et N), procédés de polymérisation, etc.
- Extraction des matières brutes: broyage, enrichissement des minerais, agglomération, etc.
- Métallurgie: raffinage, coulage, assemblage, développement d'alliages et amélioration de leurs propriétés, revêtements, protection anticorrosion, etc.
- Production de céramiques: verres, produits réfractaires, ciments, etc.
- Production de gaz industriels
- Utilisation des sous-produits et/ou des déchets
- Recherche sur les procédés de transformation des produits forestiers (pâtes et papiers)
- Fabrication de matériaux semi-conducteurs
- Fabrication de nouveaux matériaux de construction

Integrated Systems

Efficient production and assembly requires the union of machines, processes, material handling, information systems, and design into an integrated manufacturing system. Topics suitable for study include:

Manufacturing systems

- Flexible manufacturing
- Computer integrated manufacturing
- Robotics as applied to manufacturing and assembly
- Automated material handling and storage
- Computer-aided testing
- Process controls and sensors

Management Systems

- Production control, simulation and optimization
- Quality assurance and control systems
- Construction planning
- Production planning
- Integrated system design, operation and control
- Computer-aided management support systems
- Integration of design and manufacturing (CAD/CAM)

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Systèmes intégrés

Pour que la production et l'assemblage soient efficaces, il faut réunir les machines, les procédés, la manutention des matériaux et les systèmes d'information dans un système intégré de fabrication. Voici des exemples de sujets d'étude.

Les systèmes de fabrication

- Fabrication souple
- Fabrication intégrée par ordinateur
- Utilisation de robots pour la fabrication et l'assemblage
- Automatisation de la manutention et du stockage des matériaux
- Essais assistés par ordinateur
- Contrôles et détecteurs pour les procédés

Systèmes de gestion

- Contrôle, simulation et optimisation de la production
- Systèmes d'assurance et de contrôle de la qualité
- Planification de la construction
- Planification de la production
- Conception, exploitation et contrôle des systèmes intégrés
- Système de soutien de la gestion assistée par ordinateur
- Intégration de la conception et de la fabrication (CAO/FAO)

février 1985

INDUSTRIAL MATERIALS AND PROCESSES/ MATÉRIAUX ET PROCÉDÉS INDUSTRIELS

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FIELD OF RESEARCH / DOMAINE DE RECHERCHE
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- ☐ Food-Agriculture / Alimentation-Agriculture
- ☐ Communications and Computers / Telecommunications et informatique
- ■ Industrial Materials and Processes / Matériaux et procédés industriels
- ☐ Energy / Énergie
- ☐ Oceans / Océans
- ☐ Environmental Toxicology / Toxicologie de l'environnement
- ☐ Open / Ouvert

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University/Université: University of Western Ontario
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Title of Project/Titre du projet: Advanced Fluidized Bed Catalytic Cracking Technology

A microcatalytic reactor was developed with the purpose of determining the kinetic parameters corresponding to the crude oil cracking and regeneration processes. Typically, the catalyst sample was contacted during few seconds(3-4s) by an hydrocarbon pulse (case of catalytic cracking reaction) or an oxygen pulse (case of catalyst regeneration). The reactant pulse and the pulse of resulting products were measured by two independent thermal conductivity detectors. Analytical techniques and methods were developed to allow an on-line characterization of the products of coke combustion and the products of the catalytic cracking reactions. Two types of catalytic materials were extensively tested: Super D Extra catalyst from Davison-Grace suitable for the conversion of heavy crudes with high Ni and V contents, and a coked zeolitic catalyst from Imperial Oil Sarnia Refinery. In the case of the coke combustion, the specific kinetic parameters were assessed at three temperature levels: 650°C, 675°C and 700°C. However, in the case of the fast catalytic cracking transformations, the temperatures selected were: 500°C and 550°C. Three types of feedstocks were employed: a) n-$C_{16}H_{34}$, b) 75% $C_{36}H_{76}$ (paraffinic), 25% benzo(a)pyrene (aromatic), c) same as in b) but with 86 ppm of Ni and V porfirines. The data obtained in the course of this program provides a better understanding of the heavy crude cracking and coke combustion processes. This data will be the conceptual basis for an advanced catalytic cracking technology.

(Check one/cocher la case appropriée)

☐ Biotechnology / Biotechnologie
☐ Food-Agriculture / Alimentation-Agriculture
☐ Communications and Computers / Télécommunications et informatique
■ Industrial Materials and Processes / Matériaux et procédés industriels
☐ Energy / Énergie
☐ Oceans / Océans
☐ Environmental Toxicology / Toxicologie de l'environnement
☐ Open / Ouvert

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Department/Département: Chemical Engineering
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Title of Project/Titre du projet: Development of polymer production technology

The McMaster Institute for Polymer Production Technology (MIPPT) was established at McMaster University in 1982. This world-class centre for advanced polymer reaction engineering is now supported by 15 member companies located in Canada, the U.S.A. and Europe. Industrial membership fee is $15,000 U.S. per year for a minimum of 3 years. Facilities at MIPPT include computer-controlled stainless steel pressure reactors which can be operated at temperatures and pressures up to 300°C and 1500 psia in batch, semi-batch and continuous operation. These pilot-scale facilities are being used along with sophisticated computer modelling of the polymerization reactions in solution, suspension and emulsion polymerization to develop advanced processes for the production of specialty polymers such as specialty coatings, adhesives and polymer absorbents. This strategy of using computer modelling at the molecular level to identify polymerization conditions to synthesize polymers with unique properties has caught the fancy of many industrial polymer producers and their interest in this aspect of polymer research at MIPPT is the principal reason why many of the member companies have joined the Institute.

Some typical publications done under the auspices of MIPPT include:

(1) T.O. Broadhead, A.E. Hamielec and J.F. MacGregor, "Dynamic Modelling of Batch, Semi-Batch and Continuous Production of Styrene/Butadiene Copolymers by Emulsion Polymerization", Die Makromol. Chemie, in press (1985).

(2) O. Chiantore and A.E. Hamielec, "Thermal Polymerization of p-Methyl Styrene at High Conversions and Temperatures". Polymer, in press (1985).

(3) A. Penlidis, A.E. Hamielec and J.F. MacGregor, "Dynamic Modelling of Continuous Emulsion Polymerization of Vinyl Chloride", J. Vinyl Tech., 6, 134-142 (1984).

FIELD OF RESEARCH / DOMAINE DE RECHERCHE
(Check one/cocher la case appropriee)

☐ Biotechnology / Biotechnologie	☐ Communications and Computers / Telecommunications et informatique	☐ Energy / Energie	☐ Environmental Toxicology / Toxicologie de l'environnement
☐ Food-Agriculture / Alimentation-Agriculture	■ Industrial Materials and Processes / Materiaux et procedes industriels	☐ Oceans / Oceans	☐ Open / Ouvert

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Title of Project/Titre du projet:

TOUGH FIBRE REINFORCED PLASTICS

Carbon fibre reinforced plastics have high strengths and moduli, and are very light, so that their specific mechanical properties far exceed those possible with metal. Consequently, they are being widely applied in aerospace, and to a lesser extent in surface transportation.

The fibres are very brittle, and their interactions with the plastic matrix are such that the fibre composite is very brittle. This is not true to the same extent when equally brittle glass fibres are used. This was recently shown to be because of the greater Poisson's shrinkage of the glass fibre when it breaks. This shrinkage permits separation between the glass fibre and the polymer, for fibres bridging a growing crack in the composite, leading to longer fibre pull outs once the fibres break under the stress of the opening crack. This process can be reproduced, to some extent, with carbon fibres, which have much higher Young's moduli than glass, and similar Poisson's ratios. This is done by reducing the cure shrinkage of the polymer matrix. This technique has been patented in Canada and the U.S.A., and patents are pending in Europe, Japan and Australia.

The cure shrinkage of the polymer can be controlled by two methods: 1) an expanding monomer is copolymerized with the resin (typically an epoxy); 2) very small hard particles are added to the resin before cure. Both approaches have been investigated in this work, which was part of a larger program to investigate the properties of these composites and the interactions between fibres and the plastic matrix that govern them.

Carbon fibre reinforced epoxy copolymers have been manufactured using commercial fibres and epoxy resins, but with spiro orthocarbonate monomers added to control the shrinkage of the polymer during cure. These monomers were synthesized in the laboratory in sufficient quantities of make large numbers of specimens so that exhaustive testing could be carried out. Mechanical tests on the copolymers alone revealed that they had acceptable properties as matrices for the composites. Special tests to measure the shrinkage showed that this could be controlled in accordance with the requirements of the patents. The carbon fibre composites made with the copolymer matrices were up to 100% more tough than composites made with the epoxy homopolymers normally used for these fibre composites. They had compressive and shear strengths and Young's moduli which were, if anything, slightly better than those of composites made with homopolymers instead of the copolymers. Their tensile strengths were slightly less. (In addition, they had improved fatigue endurance and water resistance, as shown by work carried out under other auspices). A number of different spiro orthocarbonates were found to be effective. Scale-up of production of the monomers was shown to be practical.

Matrix shrinkage control was also achieved by the use of glass spheres. However, spheres of glass which were small enough to give an improvement in toughness were not readily available so carbon spheres are currently being investigated as an alternative. This technique provides a promising and more economic alternative to the use of copolymers.

Single fibre pull out tests have been carried out with 8 μm diameter production carbon fibres. These indicate that greater increase in toughness will be possible if, in addition to the control of polymer cure shrinkage, the fibre-polymer debonding process.

A Canadian company is taking the invention up, and is planning to produce pultrusions, prepregs, and filament wound structures based on it. Another company in Canada is currently investigating the economics of the monomer production.

☐ Biotechnology / Biotechnologie
☐ Food-Agriculture / Alimentation-Agriculture
☐ Communications and Computers / Telecommunications et informatique
■ Industrial Materials and Processes / Materiaux et procedes industriels
☐ Energy / Energie
☐ Oceans / Oceans
☐ Environmental Toxicology / Toxicologie de l'environnement
☐ Open / Ouvert

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University/Université: McMaster University, Hamilton, Ontario
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Title of Project/Titre du projet: Unmanned Machining & Robotics

Adaptive Control of Robots. Vision for Robots.

Prof. N.K. Sinha and Prof. R. Kitai - Electrical & Computer Engineering Department

Control algorithm for improving the accuracy of the trajectory of a robot using a sensor of the position of the end effector and compensating for the flexibilities of the robot.

Improvements in Vision Systems to speed up the tracking of areas of interest or moving objects.

Sensors for Unmanned Machining

Prof. J. Tlusty - Department of Mechanical Engineering

The Promess sensor for forces in rolling bearing was tested and evaluated. It may be very useful for guarding against overload in high speed spindle bearings.

Acoustic Emission signal was tested with respect to tool wear monitoring and it was found unsuitable. On the contrary, synchronized time series processing of the milling force was found very sensitive and reliable for sensing cutter tooth chipping and breakage.

Publications

1. Sinha, N.K., Karnik, A., "Modeling a Robot Arm From Sampled Input-Output Data", to be presented at the 7th IPAC Symp. on Ident. & Sys. Parameter Estimation, N.Y., England, July 1985.

2. Karnik, A., Sinha, N.K., "A Direct Approach to Modeling an Industrial Robot from Samples of Input-Output Data", Robotica (1984), Vol. 2, pp. 161-167.

3. Sinha, N.K., Karnik, A., "Adaptive Control of a Robot for Welding", MRDG Report #208, Sept. 1984, McMaster University, Hamilton, Ontario.

4. Kitai, R., Capson, D., Frendo, M., Bombera, A., "Speed Enhancement in Robot Vision Systems", MRDG Report #212, McMaster University, Hamilton, Ontario.

5. Harburn, D., "High Speed High Power Spindle for Milling", MRDG Report #202, Sept. 1984, McMaster University, Hamilton, Ontario.

6. Altintas, Y., "Tool Wear and Breakage Sensing, Section I and II", MRDG Report #200, Feb. 1984, McMaster University, Hamilton, Ontairo.

7. Altintas, Y., "Time Series Tool Breakage", MRDG Report #210, Dec. 1984, McMaster University, Hamilton, Ontario.

8. LaFlamme, R., Karnik, A., Zaton, W., "Part I: Design of an Adaptive Controller for the Unimate 2000, Part II: Report on Research Progress for the Unimate 2000 Robot", MRDG Report #211, Jan. 1985.

FIELD OF RESEARCH / DOMAINE DE RECHERCHE
(Check one/cocher la case appropriee)

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☐ Food-Agriculture / Alimentation-Agriculture
☐ Communications and Computers / Telecommunications et informatique
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☐ Environmental Toxicology / Toxicologie de l'environnement
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Title of Project/Titre du projet: Fischer Tropsch and Related Syntheses

Summary

The Fischer Tropsch Synthesis has been systematically investigated using a Cobalt on Kieselghur catalyst. The kinetics and product distribution on this catalyst have been studied over the range of 2-20 atmospheres at H_2/CO ratios from 1:1 to 60:1 and at temperatures from 195 to 230 °C. The results conform with the product distributions predicted on the basis of the Taylor-Wojciechowski formulas in sufficient detail to leave little doubt that the chain growth rules involved in developing these equations are substantially correct.

Work with supported Mn-Fe catalysts has shown that all the products observed, including paraffins, olefins and 1-alcohols are primary. This has resolved a number of hotly debated issues concerning the nature of the catalytic mechanism in the synthesis reaction.

Some of the supported catalysts have been shown to yield only high octane gasoline as product and are readily regenerated. This opens the possibility of designing a synthesis plant around a reactor-regenerator set, somewhat like the cracker-regenerator set in a conventional refinery. The prospects of such a process producing nothing but high octane gasoline and some light gases in a future synthesis plant are good. Gasoline producing catalysts which may not need regeneration at all or ones whose useful time on stream can be extended to weeks or months also seem to be possible.

At this time all experimental work on development of the catalysts is terminated because of lack of funds. Theoretical and fundamental work on the synthesis reaction will continue.

Publications

P.D. Taylor & B.W. Wojciechowski "A Quantitative Theoretical Treatment of the Fischer Tropsch Synthesis" Can. J. Chem. Eng. 61, 98-102 (1983).

N.O. Egiebor, W.C. Cooper, J. Cameron, and B. Farrand, "The Production and Testing of Iron Based Catalysts for Fischer-Tropsch Synthesis" in Catalysis on the Energy Scene, Editors: S. Kaliaguine and A. Mahay Elsevier, Amsterdam, 1984, pp. 481-488.

B. Sarup & B.W. Wojciechowski "The Effect of Time on Stream & Feed Composition on the Selectivity of a Cobalt Fischer Tropsch Catalyst" Can.J.Chem.Eng. 62, 249-256 (1984).

P.D. Taylor & B.W. Wojciechowski "The Derivation & Quantitative Evaluation of Kinetic Parameters in Fischer Tropsch Synthesis" Fuel. Proc. Technology 8, 135-147 (1984).

Plus 11 other publications in refereed journals.

STRATEGIC FIELD: OCEANS

DOMAINE THÉMATIQUE: OCÉANS

OCEANS

Oceans play a key role in the Canadian life and economy.

High quality, mission-oriented research and development is essential to improve our capability to operate at sea, often in ice-covered water, and to protect, develop and manage the ocean environment and resources for the benefit of Canadians.

Problems related to the study of the ocean need to be solved using the physical, life, and earth sciences, as well as engineering research and development. Multidisciplinary approaches are frequently necessary. Both fundamental and applied research proposals are eligible for support. It is important to note that proposals are judged on the three criteria for strategic grants: quality of the research, excellence of the applicant(s) and socio-economic relevance.

NSERC encourages applicants to propose innovative research and to demonstrate the strategic relevance to Oceans regardless of the subject areas. The following questions indicate, without priority, examples of problems of strategic importance. The list is by no means exhaustive.

- What is the nature of the coupling between atmospheric and oceanic circulations and between run off from rivers and oceanic circulation?
- How can a system as large as the ocean be more effectively sampled?
- How does ice movement couple with oceanic and atmospheric circulation?
- What are the processes and rates of geochemical cycling?
- What are the sources and sinks of chemical constituents and pollutants in the coastal zone?
- How do waves, currents, ice, and the sea floor topography influence exploration for, and exploitation of, Canadian offshore related resources?
- What is the relationship between oceanic variables and recruitment of commercial fish stocks?
- Can technology be developed that establishes the economic viability of culturing Canadian marine renewable resources?
- How can the processes controlling primary, secondary and tertiary biological production be manipulated to optimize the yield of Canada's renewable resources?
- How can prediction of fish migration and survival be improved?

LES OCÉANS

Les océans jouent un rôle crucial dans la vie et dans l'économie du Canada.

Il est donc essentiel qu'il s'effectue de la recherche et du développement de qualité supérieure orientés vers des buts précis pour améliorer l'exploitation des étendues marines, dont une bonne partie est recouverte de glace et pour protéger, exploiter et gérer l'environnement et les ressources océaniques au profit des Canadiens.

Les problèmes à résoudre dans le domaine des océans nécessitent l'intervention de spécialistes en sciences physiques, en sciences de la vie, en sciences de la Terre, et en recherche et développement en génie. Il est souvent nécessaire de faire de la recherche multidisciplinaire. Les propositions, qu'il s'agisse de recherche fondamentale ou de recherche appliquée, sont jugées selon les trois critères des subventions thématiques: la qualité de la recherche, l'excellence du ou des candidats et la pertinence socio-économique du projet.

Le CRSNG encourage les candidats à proposer une recherche innovatrice et à démontrer sa pertinence à l'étude des océans, quel que soit le sujet proposé. Voici quelques questions qui exemplifient des problèmes pertinents (la liste n'est pas par ordre de priorité et n'est pas exhaustive):

- Quelle est la nature de l'interaction entre les circulations atmosphérique et océanique et entre les écoulements des fleuves et la circulation océanique?
- Comment un système aussi vaste que l'océan peut-il faire l'objet d'un échantillonnage plus efficace?
- Quelle est la relation entre le mouvement des glaces et la circulation océanique et atmosphérique?
- Quels sont les phénomènes et le rythme du cycle géochimique?
- Quels sont les sources et les déversoirs des agents polluants et des composés chimiques dans la zone côtière?
- Comment les vagues, les courants, les glaces et la topographie des fonds marins influencent-ils l'exploration et l'exploitation des ressources au large des côtes canadiennes?
- Quelle est la relation entre les variables océaniques et le recrutement des stocks de poisson propres à la commercialisation?
- Est-il possible de mettre au point une technologie qui établisse la rentabilité économique d'une exploitation des ressources marines renouvelables du Canada?
- Comment les mécanismes de contrôle de la production biologique primaire, secondaire et tertiaire peuvent-ils être utilisés afin de maximiser le rendement des ressources renouvelables du Canada?
- Comment peut-on améliorer les prévisions de migration et de survie du poisson?

- What is the relationship between the responses of individual components of the biological system and the response of the total ecosystem to environmental stresses applied by man's activities?

- How do sedimentary processes, basin architecture, and thermal history affect the origin and evolution of the continental shelves?

- What is the relationship between geological processes, such as tectonic sea floor spreading and continental shelf evolution, and Canadian resource exploration and development?

- What paleoclimatic indicators can be measured within the sedimentary column which will help in understanding major changes in climate such as glacial episodes?

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- Quelle est la relation entre la réponse des composantes individuelles du système biologique et la réponse de l'ensemble de l'écosystème aux pressions environnementales exercées par les activités de l'Homme?

- Comment les modes de sédimentation, l'architecture du bassin sédimentaire et l'historique thermique affectent-ils l'origine et l'évolution des plateaux continentaux?

- Quelle est la relation entre les phénomènes géologiques comme l'expansion du lit des océans et l'évolution du plateau continental, et l'exploration et la mise en valeur des ressources canadiennes?

- Quels sont les indicateurs paléoclimatiques qui peuvent être repérés dans la colonne sédimentaire et qui aideront à mieux comprendre les changements climatiques majeurs comme les époques glaciaires?

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OCEANS/OCÉANS

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☐ Biotechnology / Biotechnologie
☐ Food-Agriculture Alimentation-Agriculture
☐ Communications and Computers Telecommunications et informatique
☐ Industrial Materials and Processes Materiaux et procedes industriels
☐ Energy Energie
■ Oceans Oceans
☐ Environmental Toxicology / Toxicologie de l'environnement
☐ Open / Ouvert

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Title of Project/Titre du projet: Geochemistry of Oceanic Ferromanganese Nodules

The aim of the project was to characterize the major and minor element composition and the mineralogy of ferromanganese nodules from the Pacific Ocean and to investigate in detail the relationship between the composition of the nodules and the nature and accumulation rate of the associated sediments.

A new method for determining the chemical composition of ferromanganese nodules by X-ray fluorescence spectrometry was developed. Analysis of 25 major and minor elements to a high degree of accuracy and precision can be carried out, as shown by the analysis of international reference samples of nodules and iron ores.

The chemical compositions of nodules from DOMES (Deep Ocean Mining Environment Study of the U.S. National Oceanic and Atmospheric Administration) Sites A and C in the northern equatorial Pacific were examined in detail. At Site A, the composition of the nodules varies widely and systematically over a 50 x 80 km area and is related to the surface texture of the nodules and the pattern os sedimentation. Granular nodules with high Mn/Fe ratios and high Cu, Mg, Mo, Ni and Zn contents are confined to an east-west-trending depression (>5100 m depth) where the thickness of Quaternary sediment is thin or non-existent. In contrast, smooth nodules with low Mn/Fe ratios and high As, Ca, Ce, Co, La, Pb, Sr, Ri, V, Y and Zr contents occur in slightly shallower depths (<5100 m) to the north and south of the depression. This relationship is explained by the variable influence of post-depositional (diagenetic) reactions in the associated sediments on the growth of the nodules. The most markedly diagenetic types of nodules (high Mn/Fe) are found where a bottom current, which also erodes the sediment, or prevents sedimentation, in the depression, brings remobilized metals from a remote diagenetic source to the site of deposition. There are, consequently, multiple diagenetic metal sources in the deep sea and nodules with particularly high contents of metals contributed by diagenetic reaction (Cu, Mn, Ni, etc.) will be found in areas of concentrated bottom water flow downstream from areas of sediments susceptible to diagenetic reaction.

A method for preferentially removing the Mn and Fe oxyhydroxide phases from nodules, by dilute hydroxylamine in acid solution and dilute hydrazine in basic solution, respectively, has been developed. Application of the leaching procedure to Pacific nodules allows the separation of the minor metals into groups which are associated with one or the other, or both, phases of the nodules, and helps to refine the results obtained previously from bulk chemical analysis.

A method for measuring the excess ^{230}Th and excess ^{231}Pa contents of pelagic sediments has been greatly improved to the point where results concordant with the more intricate and time-consuming radiochemical methods are produced. Application to the sediments at DOMES Site A shows that the Quaternary and the so-called Tertiary sediments accumulate at distinctly different rates and that the "Tertiary" sediment may simply represent a different Quaternary sediment facies. The method permits the survey of sedimentation rate variations over small areas of sea floor in relation to the compositional variation of associated nodules, observations that have not been possible to date.

Compositional data on nodules from throughout the Pacific Ocean, obtained from existing collections in several institutions, have also been obtained and a data bank is being prepared.

Calvert,S.E. and Piper, D.Z., 1984, Geochemistry of ferromanganese nodules from DOMES Site A, northern equatorial Pacific: multiple diagenetic metal sources in the deep sea. Geochim. Cosmochim. Acta, 48, 1913-1928.

Calvert, S.E., Cousens, B.L. and Soon, M.Y.S., 1985, An X-ray fluorescence spectrometric method for the determination of major and minor elements in ferromanganese nodules. Chemical Geology, (in press).

FIELD OF RESEARCH / DOMAINE DE RECHERCHE
(Check one/cocher la case appropriée)

☐ Biotechnology / Biotechnologie
☐ Communications and Computers / Télécommunications et informatique
☐ Energy / Énergie
☐ Environmental Toxicology / Toxicologie de l'environnement
☐ Food-Agriculture / Alimentation-Agriculture
☐ Industrial Materials and Processes / Matériaux et procédés industriels
■ Oceans / Océans
☐ Open / Ouvert

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Title of Project/Titre du projet: Studies of Oceanic Sediments and Upper Crust Using Telemetered Sonobuoys and Ocean Bottom Seismometers

The general objectives of this project are to determine the deep sediment and upper crustal structure in Hecate Strait, Queen Charlotte Sound and a region west of the Queen Charlotte Islands; and to relate the results to geological and tectonic processes of the region. The project provides sound velocity-versus-depth data in a variety of locations and identifies the general structural variations of the upper crust.

Project 1 is a 1981 seismic refraction survey of the upper crust in Queen Charlotte Sound using radiotelemetering sonobuoy sensors and a 27 litre airgun source of acoustic energy. A particular objective of the study is to determine the existence and depth extent of any sedimentary layer, hypothesized on the basis of other studies, beneath or within the Tertiary Masset volcanics in which some previous industry exploration wells had terminated. Three reversed profiles and one unreversed profile were recorded. Consistent with the earlier industry results, sediment thicknesses vary considerably throughout the study area with thicknesses varying from less than 1 km to greater than 3 km. On three of the four profiles a low velocity layer, interpreted as Mesozoic sediments, was found to lie beneath the volcanics. Thicknesses ranged from about 1 km to zero at a pinchout. The lowermost layer of all rocks is considered to be crustal rocks. Since other studies suggest that any sediments underlying the Tertiary lavas may be petroliferous, further exploration by industry is warranted.

Project 2 is associated with a major onshore-offshore refraction profile recorded in 1983 from the deep ocean west of the central Queen Charlotte Islands, across the islands and Hecate Strait to the B.C. mainland. The specific objective of that part of the project related to the Strategic grant is to provide velocity-depth structural information for the sediments and upper crust beneath Hecate Strait and across the Queen Charlotte transform fault zone west of the Queen Charlotte Islands. Four ocean bottom seismographs (OBSs) were deployed across Hecate Strait and two across the fault zone; a 32 litre airgun was the acoustic source that fired into the OBSs. The extensive data set are in the process of interpretation. Since the data are of good quality, the scientific objective will be realized.

Project 3 is a 1982 airgun/sonobuoy experiment to investigate the existence of a proposed major fault along Georgia Strait, which separates Vancouver Island from the mainland, and to determine upper crustal structure of the strait. Three basic layers or strata form the geological models interpreted to depths of ~3 km. The first layer consists of unconsolidated sediments and Pleistocene glacial deposits; the second represents late Cretaceous-early Tertiary basin fill sediments; and the third layer is likely the extension of the Coast Plutonic Complex beneath the strait. A local fault is located ~15 km northeast of Galiano Island on the west side of the strait, but the study shows no evidence for a major fault along the strait.

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FIELD OF RESEARCH / DOMAINE DE RECHERCHE
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☐ Biotechnology / Biotechnologie	☐ Communications and Computers / Telecommunications et informatique	☐ Energy / Energie	☐ Environmental Toxicology / Toxicologie de l'environnement
☐ Food-Agriculture / Alimentation-Agriculture	☐ Industrial Materials and Processes / Materiaux et procedes industriels	■ Oceans / Ocean	☐ Open / Ouvert

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Title of Project/Titre du projet: Satellite Remote Sensing of Ocean Circulation Inferred from Ice Movements and Sea Surface Temperature Patterns

This project began as an effort to study infrared satellite imagery from the AVHRR (advanced very high resolution radiometer) on polar-orbiting weather satellites. The intent was to use an image processing system in the U.B.C. Lab for Computational Vision and to acquire digital image data from A.E.S. (Atmospheric Environment Service) and C.C.R.S. (Canada Centre for Remote Sensing). These data would then be analyzed as spatial indicators of large and mesoscale temperature/circulation variations in the upper ocean.

Repeated efforts soon demonstrated the need for an image processing facility of our own and eventually our own receiving system. This was made possible by other NSERC awards in conjunction with this strategic grant. The antenna system was also made possible by a cooperative agreement with MacDonald-Dettwiler & Assoc., a local manufacturer of receiving systems. This quantum leap in technical capability has opened many new research doors and many new students (or post-docs) are pursuing research including the study of ice arching in Amundsen Gulf, primary productivity's relationship to infrared sea surface temperature (SST), the calibration of this SST using satellite-based atmospheric profiles (TOVS) and the study of ship wakes in Synthetic Aperture Radar.

Many of the specific goals of this project were also achieved. The study of imagery off the west coast has confirmed the existence of theoretically postulated baroclinic instability of the coastal current system. Study of a sequence of images has revealed the evolution of the features created by these instabilities and a numerical model has been developed that simulates this behaviour. More recently independent study of in situ ship data has confirmed the satellite results. These results have been extended to northern California and the instability mechanism is again apparent in the satellite imagery. On the west coast the satellite images have also been used to document the detailed evolution of a wind driven upwelling event.

Due to problems in acquiring useful east coast imagery plans to study ice and SST were not as fruitful. A set of about 50 images was finally obtained but only limited study was possible due to commitments to the west coast data. While a descriptive paper has been submitted (and is being revised) I am encouraged to report that the images have been sent to BIO (Bedford Institute of Oceanography) where they are using a newly acquired image processing system to study both the ice and SST problems.

FIELD OF RESEARCH / DOMAINE DE RECHERCHE
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☐ Food-Agriculture / Alimentation-Agriculture	☐ Industrial Materials and Processes / Materiaux et procedes industriels	■ Oceans / Oceans	☐ Open / Ouvert

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Title of Project/Titre du projet: "A Study in Marine Natural Products"

"A STUDY IN MARINE NATURAL PRODUCTS"

This study involved the extraction and isolation of natural compounds from a wide variety of marine organisms from the Bay of Fundy with a view to finding novel natural products, particularly those possessing antibacterial, antifungal or other significant biological activity. Over 75 organisms were included in the study in addition to some 25 marine fungi. A number of new antibacterial and antifungal agent sources have been identified and the structures of a wide variety of new biologically active natural substances have been determined by spectroscopic means.

Some Publications resulting from the research project:--

Chemical Constituents of the Starfish Asterias vulgaris
V. K. Agarwal, Ph.D. (Chemistry), U.N.B., 1982

Constituents of the Sea Cucumber Cucumaria frondosa
Anand Daljeet, M.Sc. (Chemistry), U.N.B., 1982

Aglycones from the Saponin of the Starfish Asterias vulgaris, John A. Findlay and V. K. Agarwal, J. Nat. Prod. 46, 876 (1983).

A Convenient Method for the Isolation of Amino Acids from Marine Invertebrates, John Matsoukas, Y. E. Moharir, and John A. Findlay, J. Nat. Prod. 46, 582 (1983).

Distribution of the Red Algal Epiphyte Polisiphonia lanosa on its Brown Algal Host Ascophyllum nodosum in the Bay of Fundy, C. S. Lobban and D. M. Baxter, Botanica marina XXVI, 533 (1983).

Frondogenin, A New Aglycone from the Sea Cucumber Cucumaria frondosa, John A. Findlay and Anand Daljeet, J. Nat. Prod. 47, 320 (1984).

Constituents of the Sea Cucumber Cucumaria frondosa, John A. Findlay, Anand Daljeet, John Matsoukas, and Y. E. Moharir, J. Nat. Prod. 47, 560 (1984).

Antibacterial Constituents of the Diatom Navicula delognei, John A. Findlay and Ashok D. Patil, J. Nat. Prod. 47, 815 (1984).

On the Saponins of the Starfish Asterias vulgaris, John A. Findlay, V. K. Agarwal, and Y. E. Moharir, J. Nat. Prod. 47, 113 (9184).

Marine Fungi of the Bay of Fundy VI. Growth and Metabolites of Leptosphaeria oraemaris, Sphaerulina oraemaris, Monodictys pelagica, and Dendryphiella salina, J. David Miller, Y. E. Moharir, J. A. Findlay, and N. J. Whitney, Proc. Nova Scotia Institute of Science 34, 1 (1984).

Colonization of Wood Blocks by Marine Fungi, J. David Miller, E. B. Gareth Jones, Y. E. Moharir, and John A. Findlay, Botanica Marina (accepted December 1984).

Novel Sterols from the Finger Sponge Haliclona oculata, John A. Findlay and Ashok D. Patil, Can. J. Chem. (accepted January 1985).

☐ Biotechnology / Biotechnologie
☐ Food: Agriculture / Alimentation: Agriculture
☐ Communications and Computers / Telecommunications et informatique
☐ Industrial Materials and Processes / Materiaux et procedes industriels
☐ Energy / Energie
■ Oceans / Oceans
☐ Environmental Toxicology / Toxicologie de l'environnement
☐ Open / Ouvert

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Title of Project/Titre du projet: PHYSICAL OCEANOGRAPHY OF BANKS AND SEAMOUNTS

Funding through this strategic grant has been used over five years to support research by research associates, graduate students and myself, on a large number of oceanographic problems of practical importance. These can be summarized as follows, together with references for some of the key publications on work supported in whole or in part by the grant (space does not permit a listing of all the publications).

a) Banks: Physical oceanography of Georges Bank; mean flow generation by tides, mixing on the bank, "residence time" of waters on the bank, nutrient budgets. Work cited in Canadian presentation in Gulf of Maine boundary dispute and key to future biological studies.

Loder, J.W. 1980. Topographic rectification of tidal currents on the sides of Georges Bank. J.Phys. Oceanogr., 10, 1399-1416.

Loder, J.W., D.G. Wright, C.J.R. Garrett and B.-A. Juszko. 1982. Horizontal exchange on central Georges Bank. Can. Journal of Fisheries and Aquatic Sciences, 39, 1130-1137.

b) The Bay of Fundy as an Estuary: Model that derives mixing coefficients from observed salinity, prediction of changes in salinity due to tidal power development.

Holloway, P.E. 1981. Longitudinal mixing in the upper reaches of the Bay of Fundy. Estuarine, Coastal and Shelf Science, 13, 495-515.

Garrett, C. 1984. Tides and tidal power in the Bay of Fundy. Endeavour, 8(2), 58-64.

c) Straits: Relationship of variable flow in Strait of Belle Isle to meteorological forcing, field work (with Bedford Institute) on details of flow variability, basic theory of strait flows. Leads to improved predictability, relevant to plans for cables across Belle Isle Strait and to naval activities in Strait of Gibraltar.

Garrett, C.J.R. and B. Petrie. 1981. Dynamical aspects of the flow through the Strait of Belle Isle. J. Phys. Oceanogr., 11, 376-393.

Garrett, C. and F. Majaess. 1984. Non-isostatic response of sea level to atmospheric pressure in the Eastern Mediterranean. J. Phys. Oceanogr., 14, 656-665.

d) Sea Level: Analysis of Nain, Labrador, data. Relevant to shelf circulation and sea ice-dynamics

Garrett, C., F. Majaess and B. Toulany. 1985. Sea level response at Nain, Labrador, to atmospheric pressure and wind. Atmosphere-Ocean (in press).

e) North Atlantic Sea Level and Circulation: Low frequency changes, relevant to variability of climate and fisheries.

Thompson, K.R. and M. Hazen. 1983. Interseasonal changes of wind stress and Ekman Upwelling: North Atlantic, 1950-1980. Dept. of Fisheries and Oceans. Technical Report No. 1214. 144 pp.

f) Model for the Dispersion of Radioactive Waste: Now being used by International Atomic Energy Agency for regulatory purposes. See GESAMP, Reports and Studies No. 19, IAEA, Vienna, 1983.

g) Iceberg Trajectory Analysis and Prediction: Labrador shelf mixing rates, statistical prediction scheme for iceberg trajectories.

Garrett, C., J. Middleton, M. Hazen and F. Majaess. 1985. Tidal currents and eddy statistics from iceberg trajectories off Labrador. Science (in press).

(Check one/cocher la case appropriée)

- ☐ Biotechnology / Biotechnologie
- ☐ Food-Agriculture / Alimentation-Agriculture
- ☐ Communications and Computers / Telecommunications et informatique
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- ☐ Energy / Energie
- ■ Oceans / Oceans
- ☐ Environmental Toxicology / Toxicologie de l'environnement
- ☐ Open / Ouvert

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Title of Project/Titre du projet: Investigation of the hydrothermal systems responsible for the formation of massive sulfide ore bodies in oceanic crust

This project was designed to investigate the hydrothermal pathways beneath the Cu-Zn-Fe massive sulfide ore bodies of the type currently forming on the crest of the East Pacific Rise and other mid-ocean ridges. It is thought that many Canadian greenstone belt massive sulfide ore bodies also formed as the result of the sea floor venting of mineralized high temperature hydrothermal fluids.

The investigation was carried out using research drilling and surface mapping in the Troodos ophiolite of Cyprus, an uplifted and little altered or disrupted fragment of Cretaceous oceanic crust. The massive sulfide ore bodies of the submarine lava sequence of the Troodos ophiolite have recently been shown to have formed in the same way as the East Pacific Rise bodies. Working on land in Cyprus using conventional diamond drilling has allowed access to the former hydrothermal pathways beneath ore bodies. Access to such pathways in the present mid-ocean ridges is not possible due to lack of suitable technology.

Over 900 m of research drilling was carried out in the vicinity of Agrokipia A and B pyrite-chalcopyrite-sphalerite ore bodies near the village of that name at 35°03'N, 33°09'E. 689 m Hole CY-2a at the B ore body yielded a complete section of little altered basaltic flows, argillized and weakly mineralized flows, and greenschist facies dikes with occasional screens of extrusives. A model for the formation of the body and the hydrothermal system has been devised in which upwelling was concentrated in and beneath a lava pond, as on the East Pacific Rise, with a high level dike swarm providing the best source to drive the hydrothermal system.

The Agrokipia bodies have distinctive geophysical signatures: magnetic lows due to the leaching of iron from magnetite during hydrothermal upwelling, and gravity highs, probably due to the presence of shallow, dense dike swarms; that may provide a guide to location of similar bodies in the Canadian Shield and on the mid ocean ridges.

Bibliography: A complete extensive bibliography of 56 titles is available from the principal investigator. An article in Geotimes (May 1984, pages 12-14) summarizes the field results from this investigation.

FIELD OF RESEARCH / DOMAINE DE RECHERCHE
(Check one/cocher la case appropriee)

- ☐ Biotechnology / Biotechnologie
- ☐ Food-Agriculture / Alimentation-Agriculture
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- ☐ Energy / Energie
- ☒ Oceans / Oceans
- ☐ Environmental Toxicology / Toxicologie de l'environnement
- ☐ Open / Ouvert

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Title of Project/Titre du projet: Biological Productivity in Frontal Areas in B.C. Coastal Waters.

A study of different water masses on the coast of British Columbia has been carried out. Areas of intense biological production (fronts) have been identified and they are thought to be areas of considerable importance to commercial fish species (e.g. juvenile salmon and herring) in this region.

A general view of frontal locations has been obtained using continuous underway measurements of T, S °/₀₀, nitrate and chlorophyll (fluoresence) concentrations. The major areas of input of nitrate into surface waters (excluding the Fraser River plume) were found at the southern and northern ends of the Strait of Georgia. Frontal areas in Saanich Inlet and the area south of Discovery Passage have been mapped in detail. The deep fjords on the eastern side of the Strait were found to be strongly stratified and nitrogen-limited except for local areas near shallow tidal passages. In addition to thermal effects on the front, local frontal dynamics were complicated by salinity changes and variation in topography over short horizontal scales. At both ends of the strait, horizontal advection driven by non-linear tidal effects and by density variations associated with the estuarine front between the Strait and oceans waters, can be as important as local tidal mixing. Strong year-to-year variations in frontal dynamics and associated biological production were observed as well as considerable variation in the position and extent of the front over a spring-neap tidal cycle. Primary productivity was high (4-8 $gC/m^2/day$) at the front and chain-forming diatoms were the main component of the phytoplankton. High zooplankton biomass was frequently associated with these fronts and it is inferred that these areas act as food sites for fish.

The research focussed on one key area, Discovery Passage, through field and laboratory research. The field portion provided a detailed description of variations in physical, chemical and biological parmeters over a range of spatial and temporal scales using horizontal mapping and satellite sea surface temperature data. Laboratory experiments provided a basic understanding of phytoplankton responses to two very important factors governing primary productivity in the front, light and nutrients.

FIELD OF RESEARCH / DOMAINE DE RECHERCHE
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☐ Biotechnology / Biotechnologie
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☐ Energy / Energie
■ Oceans / Oceans
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☐ Open / Ouvert

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University/Université: McGill
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Title of Project/Titre du projet: Entrainment, mixing processes and phytoplankton production in an under-ice Hudson Bay plume.

The studies focussed on the physical oceanography of a brackish plume under the ice, physical control of microalgal responses, and the physiological adaptations of the microalgae to the ice environment. Field work included two-month interdisciplinary (physical and biological) surveys, in the winters of both 1982 and 1983, on the ice pack off Great Whale River, Hudson Bay.

Studies of the physical environment showed the under-ice plume configuration of the Great Whale River to have a substantial interannual variability. Low-frequency undulations in both the offshore plume boundary and circulation have been related to large scale atmospheric pressure forcing. In Manitounuk Sound, the influence of topographically generated internal waves on salt entrainment in the upper layer was demonstrated.

The ice microflora was found to be horizontally distributed in patches, as a response to the under-ice light intensity caused by ice thickness and snow depth. The growth of microalgae at the ice/water interface was demonstrated to be influenced by the salinity of the underlying waters and nutrient limited. Nutrient replenishment of the interface is effected by fortnightly tidal cycles of vertical mixing, so that the ice microflora are controlled by energy inputs from both above (light) and below (mixing) the interface. In addition, physiological adaptations of the ice microalgae were demonstrated for the freezing temperature and the low, monochromatically blue, light environment that prevails at the ice/water interface.

Selected publications:

Gosselin, Legendre, Demers & Ingram (in press) Can. J. Fish. Aq. Sci.

Ingram. 1983. In Coastal Oceanography (H. Gade et al, eds.), Plenum Press, N.Y.

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FIELD OF RESEARCH / DOMAINE DE RECHERCHE
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☐ Biotechnology / Biotechnologie	☐ Communications and Computers / Telecommunications et informatique	☐ Energy / Energie	☐ Environmental Toxicology / Toxicologie de l'environnement
☐ Food-Agriculture / Alimentation-Agriculture	☐ Industrial Materials and Processes / Materiaux et procedes industriels	■ Oceans / Oceans	☐ Open / Ouvert

Name/Nom: Dr. Michael Isaacson
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Title of Project/Titre du projet: Design of Offshore Structures in Shallow Water

A new numerical method has been developed to provide accurate predictions of wave loading and runup on large coastal or offshore structures of arbitrary shape. Rather than providing predictions based on linear wave theory, which involves a small wave height assumption, the new method treats the complete nonlinear flow problem for the first time. In the method, the development of the flow around the structure is obtained by a time-stepp;ing procedure in which the flow at each time step is calculated by an integral equation method based on Green's theorem. The time-varying forces on the structure and the runup around it are thus obtained from the computation.

Various extensions and modifications to the basic method have been incorporated. These include extensions accounting for the effects of currents, the case of a moored, floating structure, and the corresponding two-dimensional problem applicable to floating breakwaters and bridges. A major limitation of the method is it's computation cost and complexity. The suitability of alternative approximate methods for certain situations has also been investigated.

Wave force and runup experiments were carried out in a wave basin at the University of British Columbia in order to provide comparisons with the numerical predictions. These have demonstrated the method's superiority over linear theory predictions for certain situations and have permitted an assessment of alternative approximate methods.

The results of the study should be of direct significance to the design of offshore structures in shallow water with respect to wave loading and runup.

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- ☐ Biotechnology / Biotechnologie
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- ☐ Energy / Energie
- ■ Oceans / Oceans
- ☐ Environmental Toxicology / Toxicologie de l'environnement
- ☐ Open / Ouvert

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Title of Project/Titre du projet: The effects of crude oil on parasitized cod and flounder.

Marine fish on the continental shelf off eastern Canada are often infected with parasites. Some of these are single-called flagellates called trypanosomes which live in the blood and sometimes cause a diseased condition. Recent discoveries of oil poses a threat of environmental contamination through drilling activities in the vicinity of the Grand Bank known historically for its abundance in fishery resources. The present study was initiated to ascertain the long term effects of crude oil on two species of fish, viz. Atlantic cod and winter flounder infected with the trypanosome.

The crude oil was administered as a water-soluble fraction, free of slick flowing through 3000 liter tanks and at low concentrations to cod for 12 weeks. Initial studies revealed that oil-treated fish ate less food than controls. At the end of the experiment, the oiled fish weighed less and appeared emaciated. Excess mucus was produced over the gills and fat stored in the liver was altered. In male cod, sperm production was delayed. Another experiment which involved a comparison between two crude oils suggested that a Hibernia crude, originating from the Grand Banks was more toxic to cod than a Venezuelan crude oil. The study which followed these observations involved exposure of cod, again to low concentrations of oil over a 12-week period and then infecting 50% of the group with the trypanosome. A control group was not exposed to oil but one half of these was infected with the trypanosome. The results provided evidence again of gill damage, liver changes and smaller testes in oil-treated fish. The effects were more pronounced in fish infected with the trypanosome. Exposure of cod to oil simultaneous to a trypanosome infection resulted in a significantly lower body condition, alterations in the blood and retardation of growth of the testes.

Flounder, a sedentary, bottom dwelling species, were exposed to sand contaminated with crude oil for 12 weeks. Deaths which occurred more often in juvenile fish than in adults, were highest in the groups that were infected with parasites and exposed to oil-contaminated sand. Fish which survived displayed abnormalities in their organs.

The results of these studies provide evidence that cod and flounder are not only susceptible to parasites but also crude oil potentiates the effect. Oil and drilling mud are known to be released at drill sites and potentially pose a problem of contamination. There is a need, therefore, for establishing at this time, a biological monitoring program prior to commercial oil production. It can include regular collections of samples from fish from these sites. The prevalence of visible and microscopic changes in tissues and parasite levels can be used as biological indicators of response to the toxic crude oil.

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2. Khan, R.A. and J.W. Kiceniuk. 1983. The effects of crude oil on the gastrointestinal parasites of marine fish. J. Wildl. Dis. 19: 253-258.
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1. Khan, R.A., Kiceniuk, J., Dawe, M. and Williams, W. 1981. Long term effects on crude oil on Atlantic cod. ICES C.M. 1981/E:40, 10 pp.

FIELD OF RESEARCH / DOMAINE DE RECHERCHE
(Check one/cocher la case appropriee)

- ☐ Biotechnology / Biotechnologie
- ☐ Food-Agriculture / Alimentation-Agriculture
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- ☐ Energy / Energie
- ■ Oceans / Oceans
- ☐ Environmental Toxicology / Toxicologie de l'environnement
- ☐ Open / Ouvert

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Title of Project/Titre du projet: Physical Oceanography of Arctic Straits.

Early observations of iceberg drift in Hudson Strait and Lancaster Sound revealed an opposing current structure between the two sides of these straits, with flow eastwards on one side and eastwards on the other. Similar situations nave since been uncovered by instrumental measurements in other channels of the Canadian Arctic Archipelago. Understanding the nature and the causes of that type of two-way circulation is a pre-requisite for an assessment of heat and water flow in and out of the Arctic ocean through those channels; on a more local and practical scale, it is also necessary to grasp how these flow patterns vary with depth, position and season to understand iceberg seifts in those areas and to predict where oil spills might go to.

This research has focussed on the basic dynamics of flows in and near the mouths of straits. Two specific results have been obtained. First, an analysis of the influence of changes in water depth has shown that the gradual shallowing westward into Lancaster Sound was sufficient to turn back a barotropic flow within a distance equal to about twice the width of the channel. The influence of lateral shear of the entering flow was also examined. The second study was concerned with the behaviour of a coastal current, such as the Baffin current, when approaching the mouth of a side-channel, such as Hudson Strait. The problem was stated in a general fashion and solved by successive approximations for flows around corners of arbitrary angles; combinations of corners allow the representation of flow patterns along an indented coastline including headlands, bays or side-channels. The second problem discussed flows restricted to an upper layer; an approximate superposition of the results of the two problems treated allows representation of shear flows over varying bathymetry.

These results will provide a better understanding of the circulation in the straits of the Arctic archipelago; they may be extended quite readily to the study of currents along other coastlines.

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☐ Energy / Energie
■ Oceans / Oceans
☐ Environmental Toxicology / Toxicologie de l'environnement
☐ Open / Ouvert

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University/Université: McGill
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Title of Project/Titre du projet: Predicting year-class strength in capelin.

The objective of the research supported under this grant was to develop models which provide reliable, low-cost predictions of the number and biomass of capelin (Mallotus villosus) recruiting annually to the populations located in the Canadian Northwest Atlantic. The capelin is the principal element in the diet of 10 commercially important fish species, 8 species of marine mammals, and 9 species of marine birds. It is also an important commercial species.

Studies conducted simultaneously at seven capelin spawning beaches extending over 4°40' latitude on the east coast of Newfoundland demonstrated that cyclonic atmospheric pressure systems affected incubation temperatures and the physical and biological properties of the nearshore water mass similarly and synchronously over large areas of Newfoundland's east coast in response. Egg development rates and mortality responded similarly at all sites to the integrated effects of atmospheric and water temperatures on incubation temperatures. The onset of larval drift, which is triggered by onshore wind-driven water mass exchange, was synchronous at all sites. The probability of larval survival immediately following hatching was inversely proportional to the interval between onshore winds.

The generality of these responses allowed the development of a model which predicts year-class strength for the division 2J3K (eastern Newfoundland) capelin stock. Input parameters to the model are the frequency of onshore winds subsequent to the time of median egg hatching and mean monthly water temperatures experienced by drifting larvae subsequent to that date. The model successfully predicted changes in the number and biomass of capelin resulting from reproduction occurring in the years 1966-1978. Approximately 60% of the variance is accounted for by the model.

The model has been used by Fisheries and Oceans Canada as an aid to the setting of commercial catch quotas for the species.

Publications Resulting in Whole or in Part from the Research

Frank, K.T. and W.C. Leggett. 1982. Coastal water mass replacement: its effect on zooplankton dynamics and the predator-prey complex associated with larval capelin. Can. J. Fish. Aquat. Sci. 39: 991-1003.

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Leggett, W.C., K.T. Frank, and J.E. Carscadden. 1984. Meteorological and hydrographic regulation of year-class strength in capelin (Mallotus villosus). Can. J. Fish. Aquat. Sci. 41: 1193-1201.

Frank, K.T. and W.C. Leggett (submitted). The role of macroinvertebrates as regulators of survival in larval fishes: an alternative point of view. Oecologia.

☐ Biotechnology / Biotechnologie
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■ Oceans / Oceans
☐ Environmental Toxicology / Toxicologie de l'environnement
☐ Open / Ouvert

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Title of Project/Titre du projet: Dynamics of seabird use of the marine environment in coastal British Columbia.

Research was conducted on seabirds' seasonal use of Barkley Sound and the adjacent waters of the west coast of Vancouver Island, British Columbia. This research was conducted out of the Bamfield Marine Station, with field work occurring from 1981 through 1984. We found that Barkley Sound and vicinity does not support a large biomass of breeding seabirds, compared to some other areas of Vancouver Island, for example, the Scott Islands. However, the Sound is used between late July and October as a staging area by large numbers of seabirds of several species before they migrate elsewhere to spend the winter. Barkley Sound is an important commercial fishing ground, and our knowledge of when the most seabirds are there and where they are can be used to reduce conflicts between birds and fishing activities (i.e., reducing mortality of birds in nets). The picture we have now regarding the seasonal use of Barkley Sound is also useful in perceiving periods of vulnerability to oil spills and other environmental disasters. Most species of seabird in Barkley Sound concentrate their feeding efforts on Pacific Herring, an economically important species of fish. Quantifying the food habits and the seasonal biomass of birds will give us a feeling for the impact of birds on their prey. Our results provide new information on the relationship between marine birds along Vancouver Island and the oceans on which they depend. This has been sorely neglected in Pacific Canada. As we discover the connections between seabirds and the oceans, we may be able to use the highly visible birds as indicators of other, harder to observe, marine phenomena. Seabirds, as top level predators, may provide insights into the structure and functioning of coastal marine ecosystems, because birds are highly visible and can be censused. The health of seabirds probably reflects the health of the ocean.

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☐ Energy / Energie
☒ Oceans / Océans
☐ Environmental Toxicology / Toxicologie de l'environnement
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Title of Project/Titre du projet:

Experimental assessment of urchin-algae-lobster interaction in relation to fishery development.

Green sea urchins play a significant role in determining the abundance, diversity and zonation of seaweeds in the Newfoundland Atlantic Coast sublittoral. The experimental removal of urchins (manually, or using high-calcium quick-lime) resulted in an increase of the floral and faunal biomass. Seaweeds changed from predominantly annual to predominantly perennial species. In contrast with Nova Scotia, a kelp bed (Laminaria spp.) did not develop in Newfoundland following urchin removal. There was, however, an increase in the abundance of the kelp Alaria esculenta, and a downward extension of its vertical distribution. Most of the previously urchin-dominated zone was colonized by the brown alga Desmarestia aculeata. Ice scour in the upper 2 m occurred in 3 of 5 years investigated, and it removed patches of fleshy algae. The number of recolonizing species increased following ice scour. In the absence of ice scour a dense canopy of Alaria esculenta developed, resulting in the exclusion of most other seaweed species from the very shallow subtidal zone. Ice scour did not affect the zone from which urchins had been removed.

The sea urchins have a low growth rate, high mortality and strong interannual variation in recruitment. Growth rate and reproductive maturation are linked with the availability of preferred food species. Animals taken from poor habitat and held in boxes provided with unlimited preferred food show an increase in gonad development, indicating a potential fishery/aquaculture application. While lobsters prey on urchins, fish are also important predators: the Ocean Pout (Macrozoarces americanus; 50-60% urchin diet), the Atlantic Wolffish (Anarhichas lupus; 80-90% urchin diet), the Winter Flounder (Pseudopleuronectes americanus; 5-19% urchin diet) and the Cunner (Tautogolabrus adspersus; 14% urchin diet). The first two species feed on the larger urchins, the last two on the juveniles.

The restoration of a diverse sublittoral community dominated by perennial seaweeds will have economic potential and a significant fishery application. The enhanced cover of fleshy seaweeds provides shelter for juvenile codfish, which utilize it preferentially. Studies on the Ocean Pout and the Atlantic Wolffish will be of benefit to fishery biologists who currently have few data on these underutilized commercial species. A significant result of this study is the identification of the roles of the principal species in the nearshore ecosystem, as this will enhance and facilitate multispecies approaches to their management.

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■ Oceans / Oceans
☐ Environmental Toxicology / Toxicologie de l'environnement
☐ Open / Ouvert

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Title of Project/Titre du projet: Environmental Controls on Deep Water Community Development

In anticipating how a system might react to the exploitation of natural resources, one is dealing with the science of change. To develop useful predictive models, it is necessary to i) establish standard descriptive methods; ii) estimate natural variation in th system; and iii) recognize induced change beyond that variation.

In the fjords of British Columbia, unusual deep water communities flourish within meters of the shore. The sheer rock walls support animals usually found in the deep ocean; many animals are adapted solely to this habitat - finding new species is common. The wall surface of these long, sinuous fjords presents a huge area for community development: communities exposed directly to whatever turbulence, sediment or chemicals the surrounding water brings them. The coast is sponsoring the growth of depots servicing mining, forestry, shipping and municipal enterprises. This research project was established to investigate the nature of these wall communities, the kinds of natural disturbances they could endure, and the extent to which they may react to and indicate induced changes.

The Institute of Ocean Sciences (Fisheries and Oceans) is gratefully acknowledged for their support of this programme through their submersible PISCES IV. This vessel is a unique Canadian resource in its capacity of bring the observer to the study site and to measure many environmental characteristics. Ten fjords were studied to make photographic inventories of the wall habitats down to 700 m depth. Images gave information (detail to 1 cm) on species type, abundance, size, association, range and dominance. Indices of community diversity and biomass can be computed and compared.

These fjords support a surprisingly high biomass, many novel and exotic species, and distinctive associations. Exchange of larvae among fjords appears limited: repopulatio of a disrupted habitat would be relatively slow. Each fjord seems to have a community peculiar to the conditions present. Two fjords experience oxygen levels below those normall expected to support life. Surprisingly, community diversity and biomass were very high. Three fjords in which glacial sediment loading was high showed lower animal abundances but many organisms were specific species indicative of these extreme conditions. Part of the study continues to investigate the change of the deep community over the years to determine if the community oscillates around equilibrium conditions or slowly changes character as the oxygen levels fluctuate on an annual basis.

Initial results indicate that many animals survive extreme natural conditions; if nutrients are not limiting, the communities continue to grow until space constrains growth. Most of the natural disturbances are periodic phenomena that decimate local groups but repop lation from very close populations is possible. These effects suggest that similar human-induced changes may not always be devastating; in fact, brief and intense disturbances may be better than low-level continuous pollution. Several areas influenced by mill and mine effluents were examined. The same 'stressed' species assemblages were present and in lower abundances. Deep waste disposal in poorly flushed areas could indeed threaten an unusual and productive community. Many commercial species are also present but with some care over disposal methods, these groups may show greater tolerance than previously anticipated.

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FIELD OF RESEARCH / DOMAINE DE RECHERCHE
(Check one/cocher la case appropriee)

- ☐ Biotechnology / Biotechnologie
- ☐ Food-Agriculture / Alimentation-Agriculture
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- ☐ Energy / Energie
- ■ Oceans / Oceans
- ☐ Environmental Toxicology / Toxicologie de l'environnement
- ☐ Other / Divers

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Title of Project/Titre du projet: Geologic buffering of the global carbon cycle

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Geologic buffering of the global carbon cycle

The magnitude of the presently known global CO_2 sinks does not appear large enough to account for the "missing" anthropogenic CO_2 in the present day atmosphere. This consideration, the information from ice trapped ancient gases, from southern hemisphere tree rings, and from geologic record in carbonates suggest the presence or large natural fluxes in the global carbon cycle. It is essential that these fluxes be quantified in order to evaluate their possible contribution to the observed post-1950 atmospheric CO_2 increase. The knowledge of the latter is, in turn, fundamental for predictions of the CO_2 greenhouse effect, with its possibly detrimental climatic consequences. The signature of such natural carbon transfers among terrestrial reservoirs is a variation in $\delta^{13}C$ of seawater bicarbonate. The latter is recorded in $CaCO_3$ layers of coeval shells. The results of the present study confirmed the existence of these variations for the Paleozoic and showed that geologic tectonic control is the forcing function of perturbations in carbon cycle on geologic time scales (>10^7 years). The long term average fluxes are about one order of magnitude smaller than the presently accepted anthropogenic rates of CO_2 release from fossil fuels. On shorter time scales (<10^6 years), the perturbations are caused but internal dynamics of the ocean-atmosphere-biosphere system within the overall constraints imposed by the long-term controlling geologic phenomena. These shorter term variations are therefore of lesser total magnitude, but the rates of transfers of carbon among various reservoirs are faster, approaching those of the anthropogenic origin. Thus the natural system is more strongly buffered and more responsive to anthropogenic perturbations than previously anticipated. This will likely dampen the impact of the anthropogenic CO_2 release and thus the magnitude as well as consequences of the postulated CO_2 greenhouse.

The present data also indicate that oxygen isotopic composition of seawater likely changed during the late Paleozoic. At present no easy explanation is available for this observation. On the other hand, the resolution of seawater $^{18}O/^{16}O$ composition during the Phanerozoic may improve the utility of the oxygen isotope paleothermometer for the 200-570 million years BP time interval of geologic history.

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- [ ] Energy / Energie
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- [ ] Environmental Toxicology / Toxicologie de l'environnement
- [ ] Open / Ouvert

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Title of Project/Titre du projet: Marine Geodesy

The work completed under this project helps provide Canada with the tools needed to exercise effective sovereignty and management of resources and environment over her offshore and inshore marine areas. Several advances in reliable and accurate positioning at sea were achieved. Marine navigation systems based on the new USAF satellite-based Global Positioning System were developed, in collaboration with Nortech Surveys Limited of Calgary, and the Bedford Institute of Oceanography. An Apple-computer-based navigation, echo sounding and data logging system was designed, built and tested, which is suitable for use in small survey launches, and much less expensive than existing systems. Improvements in the methods used to correct and calibrate the LORAN-C lattices printed on Canadian Hydrographic Charts were developed. An efficient helicopter-based technique using differential LORAN-C, to check whether navigational buoys have been moved off position by a storm, was tested for the Canadian Coast Guard. Methods for correcting tide gauge records for biases due to meteorological and other causes was perfected, and applied to the tide gauges in Eastern Canada.

A total of 55 publications resulted from this work. The research work of 16 postgraduate students, and of 20 research assistants was supported by the project. The various studies involved collaborations, consultations, and exchanges with many other organizations: eleven Canadian companies, seven Candian government agencies, departments in three other Canadian universities, ten agencies in the United States, and eleven other universities around the world.

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Title of Project/Titre du projet: GEOPHYSICAL COMPILATION MAPS OF THE ATLANTIC MARGIN OF NORTH AMERICA

Geophysical maps are useful in interpreting surface geology and deep crustal structure. They are especially important in areas of no rock exposure. The primary objective of this strategic research proposal was to compile Magnetic Anomaly and Bouguer Gravity Anomaly maps of Atlantic Canada covering the onland Appalachian Mountain Chain and extending offshore to the morphologic edge of the continental shelf. The project was undertaken to gain further insight into the geology and makeup of the Atlantic continental margin which is Canada's newest frontier for petroleum exploration. Recent major petroleum discoveries have brought considerable attention to the structure and evolution of the offshore area.

Petroleum deposits of the Grand Banks and Scotian Shelf are contained in relatively young cover rocks that overlie the submerged extensions of the onland Appalachian Mountain System. The distribution and thickness of the petroleum-bearing cover rocks in places reflect deeper structures of Appalachian basement rocks. Clearly, an understanding of Appalachian basement rocks and the recognition offshore of onland zonal subdivisions and their boundaries bear upon an understanding of the structural evolution of the Atlantic margin and the distribution, thickness and structures of petroleum-bearing cover rocks.

The objective of the strategic research proposal was met. Both the Magnetic Anomaly and Bouguer Gravity Anomaly maps are now printed, in colour and at a scale of 1:2,000,000. Approximately 1,000 copies of each map have been distributed to the user sector, including industry, government departments, universities and libraries. Another 2,000 copies of each map are on hand at Memorial University and are available upon request.

The Magnetic Anomaly Map clearly reflects the surface geology of the Appalachian Mountain System and allows the extension of its major zonal subdivisions and boundaries across the continental shelf. Noteworthy is the clear expression of the Avalon-Meguma zone boundary across the Grand Banks (Collector Magnetic Anomaly). Magnetic highs of the Grand Banks are equated with volcanic belts of the Appalachian Avalon zone.

Similarly, the Bouguer Gravity Anomaly Map portrays onland rocks and structures and allows their extension across the submerged continental margin. The gravity also reflects density of the crust and provides insight into deep structure. A marked gravity gradient coincides with the morphologic shelf edge, except in northeast Newfoundland where it lies more inboard and thus signals peculiarities in structures there. Deep basins of petroleum-bearing cover rocks overlie attenuated underlying crust; collectively leading to a less dense crustal section and negative gravity expression. Thus the Jeanne D'Arc and Avalon basins, important for the Hibernia and other major petroleum discoveries, are marked by a prominent negative Bouguer Anomaly.

The geophysical compilation maps are useful in formulating evolutionary models of the Atlantic margin. They are also important in comparisons between the modern Atlantic margin and the ancient continental margin of eastern North America whose rocks are now entailed in the Appalachian Mountain Chain. The geophysical maps, when viewed in conjunction with geological and other thematic maps lead to new ideas and theories that require future testing. This is an expectable outcome of any good compilation. Maps are the way in which geologists and geophysics communicate. They are therefore a dynamic force in earth sciences.

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STRATEGIC FIELD: OPEN

DOMAINE THÉMATIQUE: OUVERT

Natural Sciences and Engineering Research Council of Canada

Conseil de recherches en sciences naturelles et en génie du Canada

THE OPEN AREA

The Open Area is a category in the Strategic Grants Program in which awards are made to support research projects in areas of national concern other than those already identified for support (i.e. biotechnology, communications and computers, energy, environmental toxicology, food/agriculture, industrial materials and processes and oceans).

Two types of research are eligible for support in the Open category. The first is research aimed primarily at the utilization, application and further development of existing knowledge and expertise, including technology transfer. The second is general development and creation of knowledge and expertise in specific areas of national concern (other than the seven areas chosen by NSERC).

Proposals should fall into one of the following two broad categories in order to justify funding:

1. science and engineering for industrial and socio-economic benefit;

2. science for public policy, i.e. the application of concepts and knowledge to issues of public policy.

The Open Area is an invitation to the research community to participate actively in the definition of new areas of research that are in the national interest by submitting innovative and challenging proposals.

Examples of subject areas for which strategic grants have been awarded in the Open Area include:

Biomedical engineering
Forestry
Geo-sciences
Instrument development
Lasers
Low-temperature physics
Pest management
Surface science
Transport
Water resources management

Note that these are only a few examples of the many subject areas (other than the seven identified fields) that are eligible for support in the Open Area.

The Open Area is not intended to be a substitute for regular NSERC grant programs and Council expects that it will complement or fill possible gaps in the mechanisms and operation of NSERC, or in the spectrum of research and research-related activities supported by NSERC.

LE THÈME OUVERT

Le thème ouvert est un volet du programme de subventions thématiques dans le cadre duquel le Conseil subventionne des projets de recherche dans des domaines d'intérêt national autres que ceux qui ont été désignés (c.-à-d. alimentation et agriculture, biotechnologie, énergie, matériaux et procédés industriels, océans, télécommunications et informatique, toxicologie de l'environnement).

Deux types de recherches sont admissibles dans le cadre du thème ouvert. D'une part, on considère les recherches visant principalement à l'utilisation, à l'application et au développement ultérieur de connaissances et de compétences acquises, y compris le transfert technologique. D'autre part, on admet aussi les recherches visant principalement au développement général et à la création de connaissances et de compétences dans des domaines précis d'intérêt national (autres que les sept domaines choisis par le CRSNG).

Les recherches doivent relever d'une des deux grandes catégories suivantes:

1. la science et le génie visant à des retombées industrielles et socio-économiques;

2. la science à l'appui de l'intérêt public, c.-à-d. l'application de concepts et de connaissances à des questions d'intérêt public.

Ce volet du programme thématique constitue une invitation du Conseil aux chercheurs universitaires à participer activement à la définition de nouveaux domaines de recherche d'intérêt national en soumettant des propositions innovatrices et intéressantes.

Voici des exemples de domaines de recherche déjà subventionnés dans le cadre du thème ouvert.

Conception et réalisation de nouveaux appareils
Foresterie
Génie biomédical
Gestion des ressources en eau
Lasers
Lutte intégrée contre les insectes nuisibles
Physique des basses températures
Sciences de la terre
Science des surfaces
Transport

Veuillez noter qu'il ne s'agit là que de quelques exemples. De nombreux sujets (autres que les sept thèmes du programme) sont admissibles au domaine ouvert.

Ce thème "ouvert" n'est pas un substitut aux programmes ordinaires du CRSNG, et le Conseil s'attend à ce qu'il vienne combler certaines lacunes ou compléter les mécanismes et le fonctionnement du CRSNG ou la gamme d'activités de recherche ou d'activités liées à la recherche appuyées par le CRSNG.

OPEN/OUVERT

NAME/NOM DEPARTMENT/DÉPARTEMENT UNIVERSITY/UNIVERSITÉ		PAGE
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Tavenas, F. Génie civil Laval	Etude de la compressibilité et de la consolidation des argiles	204
Tulip, J. Electrical Eng. Alberta	Laser neurosurgery	205

(Check one/cocher la case appropriee)

☐ Biotechnology / Biotechnologie	☐ Communications and Computers / Telecommunications et informatique	☐ Energy / Energie	☐ Environmental Toxicology / Toxicologie de l'environnement
☐ Food-Agriculture / Alimentation-Agriculture	☐ Industrial Materials and Processes / Materiaux et procedes industriels	☐ Oceans / Oceans	■ Open / Ouvert

Name/Nom: C. Bouchard, F. Landry, P. Lagassé, M.R. Boulay, A. Tremblay, G. Thériault
Department/Departement: Laboratoire des sciences de l'activité physique
University/Université: Université Laval, Ste-Foy, Québec
Phone number (optional)/N° de telephone (facultatif): (418) 656-7003
Title of Project/Titre du projet: Les causes des variations dans l'adaptation des propriétés de la machine humaine sous l'influence de l'entraînement physique.

La force musculaire et les capacités et puissances aérobies et anaérobies de la machine humaine peuvent être augmentées sous l'influence d'un programme d'entraînement physique propre à ces attributs, tandis que la graisse corporelle et son métabolisme peuvent être modifés considérablement, par l'accroissement de la dépense d'énergie associée à l'entraînement ou par la suralimentation chronique. Toutefois, ces conclusions générales sont dérivées des changements obtenus en moyenne lors d'études expérimentales dans lesquelles on n'accordait pas d'importance particulière aux différences individuelles dans l'adaptation. Or ces différences inter-individuelles dans la réponse à l'entraînement physique existent et elles sont considérables. Le présent programme de recherche avait comme objectifs principaux: a) de quantifier la variation humaine observée dans la réponse à l'entraînement, b) et d'identifier les causes de la variation dans l'adaptation à l'entraînement. Nous avions fait l'hypothèse que la trainabilité des divers attributs de la machine humaine pourrait varier en fonction du sexe, des expériences antérieures d'entraînement, du niveau courant de l'attribut et de l'hérédité (i.e. de variations génétiques inconnues). Au total, 12 études différentes furent conduites dans le cadre de ce programme grâce à la collaboration de 47 paires de jumeaux(elles) monozygotes, de 76 sujets sédentaires et de 43 sujets contrôles. Dans le cas de la capacité et de la puissance aérobies, les résultats indiquent que le niveau courant du phénotype est associé à environ 25% de la variation dans la trainabilité tandis que le génotype semble responsable de la plus grande partie des différences individuelles dans la réponse à l'entraînement aérobie. Certaines personnes n'ont aucune trainabilité pour ces propriétés, alors que d'autres (environ 10%) progressent de plus de 50% dans les mêmes conditions d'entraînement. Au plan des capacités et puissances anaérobies, la trainabilité est comparable chez les deux sexes. Ces attributs sont caractérisés par de grandes différences inter-individuelles dans la réponse à l'entraînement de haute intensité par intervalles, mais ces variations ne sont pas distribuées aléatoirement. Ainsi, on observe que l'hérédité explique environ 50% des variations dans l'adaptation de la capacité anaérobie alactacide et près de 80% pour la capacité anaérobie lactacide. Le rôle du génotype dans les adaptations des enzymes des voies énergétiques du tissu musculaire semble toutefois plus modeste. Comme l'ont démontré nos observations sur l'entraînement des jumeaux(elles) monozygotes, la sensibilité à l'entraînement de la force maximale, et les changements dans les types de fibres musculaires et pour quelques enzymes du muscle dépendent dans une large mesure (40% à 80% de la variance) de l'hérédité. Dans ce cas, le sexe des sujets et leurs expériences antérieures d'entraînement pourraient possiblement être associés à la sensibilité à l'entraînement, mais ces effets semblent plutôt modérés. Dans le cas de la graisse corporelle et du métabolisme du tissu adipeux, nous nous sommes penchés non seulement sur les effets de l'entraînement aérobie prolongé mais également sur les conséquences de la suralimentation chronique (22 jours). Nous avons conclu que les hommes sont plus sensibles que les femmes dans la perte de graisse et dans les changements métaboliques associés au bilan énergétique négatif de l'entraînement physique. Lors de la suralimentation chronique, les changements dans la graisse corporelle totale, la distribution de la graisse superficielle, le métabolisme de repos et la réponse thermique à un repas sont significativement reliés au génotype. En bref, ce programme de recherche aura permis de mettre en évidence le fait qu'une proportion appréciable de la population ne jouit pas d'une capacité notable d'adaptation pour un attribut donné, certains individus ayant une trainabilité à peu près nulle. Par ailleurs, on rencontre des personnes dont le pouvoir d'adaptation est élevé face à un type d'entraînement donné ou à la suralimentation chronique. La sensibilité de l'organisme dans la réponse au stress semble déterminée en grande partie par l'hérédité.

FIELD OF RESEARCH / DOMAINE DE RECHERCHE
(Check one/cocher la case appropriee)

☐ Biotechnology / Biotechnologie
☐ Food-Agriculture / Alimentation-Agriculture
☐ Communications and Computers / Telecommunications et informatique
☐ Industrial Materials and Processes / Materiaux et procedes industriels
☐ Energy / Energie
☐ Oceans / Oceans
☐ Environmental Toxicology / Toxicologie de l'environnement
■ Open / Ouvert

Name/Nom: Gilbert DROUIN
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University/Université: Ecole Polytechnique de Montréal
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Title of Project/Titre du projet: Elaboration d'un modèle biomécanique du genou

Les articulations sont une intégration fonctionnelle des os, des muscles et des ligaments. Les os forment la composante structurale, les muscles sont la source d'énergie et les ligaments les stabilisateurs. Une synergie entre ces trois composantes assurent le mouvement et la stabilité. Le rôle respectif de chacune des ces structures lors de mouvement est encore indéterminé. Deux approches sont possibles pour étudier ce problème, l'approche expérimentale et l'approche modélisation, les deux complémentaires. La subvention thématique a proté sur l'élaboration d'un modèle biomécanique du genou.

Le modèle mathématique est un outil de représentation géométrique et fonctionnel des structures qui composent le genou. Il est constitué de trois parties principales: la description géométrique des os en présence, la représentation du comportement biomécanique des structures élastiques et un algorithme de solution. A ceci sont superposés des moyens graphiques d'input/output.

La représentation géométrique est obtenue en numérisant point par point les surfaces osseuses. Ces coordonnées spatiales peuvent permettre de générer des surfaces au moyen de techniques d'interpolation ou de définir des coordonnés d'éléments finis. Le comportement biomécanique est décrit par la rigidité des structures élastiques obtenue de nos travaux ou de la littérature. L'algorithme de solution est basé sur des techniques d'éléments finis appliqués à des éléments qui subissent de grandes déformations et qui ont un comportement nonlinéaire. Il s'agit d'un processus itératif basé sur la méthode de Newton-Raphson.

L'input/output se fait au moyen d'un interface graphique implanté sur un terminal couleur à haute resolution. L'utilisateur peut "manipuler" sur l'écran chacune des composantes du genou afin d'étudier une position relative spécifique, définir les structures et leur site d'insertions et appliquer des forces. Le résultats de ce chargement sera illustré par le même interface qui permet de visualiser les mouvements subis par le os et les forces dans les structures en incluant les forces de contact.

Les équipements utilisés sont un numérisateur,un mini ordinateur Vax/750, et un terminal graphique Megatek (DIS-RF) assujetti à un logiciel Megatek 7295/J.

Le modèle peut être utilisé pour comprendre le mécanisme de fonctionnement des articulations et le rôle respectif de chacune des structures modélisées. De plus, il permet d'évaluer conceptuellement une procédure chirurgicale. Une attention particulière a été portée afin de rendre son utilisation la plus transparente possible.

FIELD OF RESEARCH / DOMAINE DE RECHERCHE
(Check one/cocher la case appropriee)

- ☐ Biotechnology / Biotechnologie
- ☐ Food-Agriculture / Alimentation-Agriculture
- ☐ Communications and Computers / Telecommunications et informatique
- ☐ Industrial Materials and Processes / Materiaux et procedes industriels
- ☐ Energy / Energie
- ☐ Oceans / Oceans
- ☐ Environmental Toxicology / Toxicologie de l'environnement
- ☑ Open / Ouvert

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STRATEGIC Grant

Name/Nom: DEL G. FREDLUND
Department/Département: CIVIL ENGINEERING
University/Université:
Phone number (optional)/N° de telephone (facultatif): 306-966-5336
Title of Project/Titre du projet: Engineering Behavior of Expansive Soils

Summary of Strategic Research Projects

Research under the above strategic grant was undertaken in order to better understand the complex behavior of unsaturated expansive soils. These soils pose a severe and costly problem primarily on the prairies in western Canada.

Research was directed towards the following aspects.

i) Coupling Climatic Data to the Modeling of Heave. These studies were initiated but not completed. Further studies are ongoing.

ii) Shear Strength of Unsaturated Soils. Triaxial and direct shear testing equipment has been modified and procedures have been developed for testing unsaturated soils. The procedures are practical and suitable for use in consulting practice. The theory related to the application of the results in practice, has been published in research papers.

iii) Prediction of Lateral Earth Presures. Unsaturated soils often exert high lateral pressures against retaining structures. The use of the unsaturated soil theory has led to the formulation of procedures to estimate these pressures.

iv) New Devices to Measure Negative Pore-Water Pressure. Over the past 3 years several new devices and techniques have been evaluated at the University of Saskatchewan. The MCS and Agwatronics (thermal conductivity) Gauges have proven quite satisfactory for the 0 to 3 atmosphere suction range. The psychrometers have proven quite satisfactory for higher suctions in a laboratory environment. The filter paper technique is satisfactory as a rough indicator of the suction.

v) Movement of Moisture. Two- and three-coupled and uncoupled models have been formulated for unsaturated soils. Computer codes have been written and tested for two-dimensional steady state and transient flow models.

vi) Design Procedures. Research papers have been published which deal with design procedures related ground movements and slope stability. In each case, the change in soil suction is related to changes in the soil properties.

Further studies, funded from other sources are presently underway on many of the above topics.

FIELD OF RESEARCH / DOMAINE DE RECHERCHE
(Check one/cocher la case appropriée)

☐ Biotechnology / Biotechnologie
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☐ Energy / Énergie
☐ Environmental Technology / Technologie de l'environnement
☐ Food-Agriculture / Alimentation-Agriculture
☐ Industrial Materials and Processes / Matériaux et procédés industriels
☐ Oceans / Océans
■ Open / Ouvert

Name/Nom: TAVENAS, F., LEROUEIL, S.
Department/Département: DEPARTEMENT DE GENIE CIVIL
University/Université: UNIVERSITE LAVAL
Phone number (optional)/N° de téléphone (facultatif): (418) 656.3170; (418) 656.2601
Title of Project/Titre du projet: ETUDE DE LA COMPRESSIBILITE ET DE LA CONSOLIDATION DES ARGILES

Dans une première partie de la recherche, la perméabilité des sols argileux a été étudiée. Des techniques fiables de mesure du coefficient de la perméabilité k au laboratoire et in situ ont été développées; en particulier le perméamètre autoforeur s'avère un excellent appareil pour mesurer la perméabilité en place. Les facteurs contrôlant k (indice des vides, propriétés physiques, température) ont aussi été étudiés.

Dans une deuxième partie, il a été montré par des essais oedométriques spéciaux à vitesse de déformation constante, à grandient contrôlé, à chargement par paliers ou de fluage que la compressibilité des argiles est contrôlée par une loi unique contrainte-déformation-vitesse de déformation. L'étude détaillée de sous-couches bien identifiées de fondations argileuses de trois remblais permet de conclure que cette loi rhéologique est aussi valide in situ dans le domaine normalement consolidé.

Un modèle numérique prenant en compte les conclusions des études expérimentales sur la perméabilité et la compressibilité a été développée pour des couches d'argile homogène.

Publications:

Kabbaj, M., Oka, F., Leroueil, S. Tavenas, F. 1985. Consolidation of natural clays and laboratory testing. ASTM Symposium on Consolidation of Soils - Laboratory Testing. Fort Lauderdale. In press.

Leroueil, S., Kabbaj, M., Tavenas, F., Bouchard, R. 1985. Stress-strain-strain rate relationship for the compressibility of natural clays. Géotechnique. In press.

Flon, P., Leroueil, S., Tavenas, F. 1985. Perméabilité des argiles: effet de la température et effet de chimie du liquide perméant. Rapport interne en préparation, Département de Génie civil, Université Laval, Québec.

Kabbaj, M., Leroueil, S., Tavenas, F. 1984. Construction du remblai expérimental de Berthierville. Rapport interne GCS-84-01, Département de Génie civil, Université Laval, Québec.

Leroueil, S., Tavenas, F., Samson, L., Morin, P. 1983. Preconsolidation pressure of Champlain clays - Part II - Laboratory determination. Canadian Geotechnical Journal, Vol.20(4):803-816.

Mesri, G., Tavenas, F. 1983. Discussion on "Permeability and consolidation of normally consolidated soils" by Samarasinghe et al. (1982). ASCE, GED: Vol.109(6):873-878.

Tavenas, F., Jean, P., Leblond, P., Leroueil, S. 1983. The permeability of natural clays - Part I - Methods of laboratory measurement. Canadian Geotechnical Journal, Vol.20(4): 629-644.

Tavenas, F., Tremblay, M., Leroueil, S. 1983. Mesure in situ de la perméabilité des argiles. Symposium international / Reconnaissance des sols et des roches par essais en place. Paris, Bulletin de l'Association internationale de Géologie de l'Ingénieur: 509-515.

Bouchard, R., Tavenas, F. 1982. Etude du tassement de remblais par CONMULT - Remblai autoroute 20, Saint-Zotique. Présenté au MERQ. Rapport interne, GCS-82-03, Département de Génie civil, Université Laval.

Bouchard, R., Tavenas, F., Leroueil, S. 1982. Méthode de calcul du tassement des remblais sur fondation argileuse. Rapport interne GCS-82-05, Département de Génie civil. U. Laval.

FIELD OF RESEARCH / DOMAINE DE RECHERCHE
(Check one/cocher la case appropriee)

☐ Biotechnology / Biotechnologie
☐ Food-Agriculture / Alimentation-Agriculture
☐ Communications and Computers / Telecommunications et informatique
☐ Industrial Materials and Processes / Materiaux et procedes industriels
☐ Energy / Energie
☐ Oceans / Oceans
☐ Environmental Toxicology / Toxicologie de l'environnement
■ Open / Ouvert

Name/Nom: John Tulip
Department/Département: Electrical Engineering
University/Université: University of Alberta, Edmonton, Alberta, T6G 2G8
Phone number (optional)/N° de telephone (facultatif):
Title of Project/Titre du projet: Laser Neurosurgery

This project was in support of developmental research into neurosurgical lasers. The goal of the project was to build a combined CO_2 and NdYAG laser adapted for neurosurgical animal and clinical research. The project has resulted in waveguide CO_2 laser fabrication and processing facilities and a hard sealed waveguide laser of forty watts output power. A compact waveguide surgical laser delivery arm has been developed and microelectronic system control and monitoring has been completed. A CO_2 surgical laser system will be completed by the summer of 1985. A NdYAG laser has been built in a prototype form and is being used as a model for a clinical system which is currently under construction. This system is different from conventional medical NdYAG laser in that it will oeprate continuously or in Q switched pulse mode which enhances its cutting capability.

The CO_2 and NdYAG lasers will be combined into a single neurosurgical laser and used for animal and clinical studies in the summer of 1985.

REGULATIONS GOVERNING THE USE OF GRANT FUNDS
(Excerpts from 1985-86 Awards G ide) /

RÈGLEMENTS RÉGISSANT L'UTILISATION DES SUBVENTIONS
(extraits du Guide des subventions 1985-1986)

Description

86. Strategic grants are offered to individuals and groups to assist with the direct operating costs of research projects or programs (including the organization of workshops and seminars) or with the purchase of equipment essential to the pursuit of a research program in the following areas:

— biotechnology
— communications and computers
— energy
— environmental toxicology
— food/agriculture
— industrial materials and processes
— oceans

In addition, through an "open" area, researchers may submit proposals in fields of national concern other than the seven designated areas.

Strategic conference grants assist with the organization of conferences in areas of national concern.

General Principles

200. Grant funds must be used effectively, economically, and in the best interest of the research supported by the grant. The financial administration of grants and the conditions governing their use are intended to restrict grantees as little as possible, but require good accounting and administrative practices.

Commitments

210. NSERC receives funds for its programs on the basis of annual parliamentary appropriations. Thus, all commitments for support beyond the current fiscal year (e.g. second and third instalments of two- and three-year grants) are made subject to the availability of funds. Under no circumstances is NSERC able to accept responsibility for commitments incurred by grantees which exceed the actual funds to their credit in the NSERC Common Grant Account at the university.

Fiscal Period

207. NSERC grants are awarded to cover expenditures incurred during a specific period of time termed the fiscal period.

The fiscal period for strategic grants commences on November 1 of the year of the initial award and may be of a one-, two- or three-year duration.

Overhead

214. The funds provided through NSERC grants in aid of university research must not be used to contribute to the payment of indirect or overhead costs of research.

Payment of Salaries and Stipends

217. NSERC grantees may use their research grant funds to contribute towards the payment of salaries or stipends of qualified people working in their laboratories on a part-time or full-time basis. However, grant funds must not be used to pay any part of the salary of the grantee, members of the grantee's immediate family, other members of the staff of a Canadian university whose status would make them eligible to apply on their own behalf for NSERC grants, or recipients of other direct NSERC support. Grant funds must not be used to employ secretaries, but may be used to pay for typing services for manuscripts and reports.

Description

86. Les subventions thématiques sont accordées à des chercheurs individuels ou à des groupes pour aider à couvrir les frais directs de programmes (y compris l'organisation de colloques et séminaires) ou de projets de recherche ou pour l'achat d'appareils nécessaires à la poursuite de travaux de recherche dans les domaines suivants:

— alimentation et agriculture
— biotechnologie
— énergie
— matériaux et procédés industriels
— océans
— télécommunications et informatique
— toxicologie de l'environnement.

Il existe également un thème «ouvert», dans le cadre duquel les chercheurs peuvent soumettre des propositions dans des domaines d'intérêt national autres que les sept thèmes choisis.

Les subventions thématiques pour conférences soutiennent l'organisation de conférences dans des domaines d'intérêt national.

Principes généraux

200. Les subventions doivent être utilisées de façon efficace et économique, de manière à favoriser le plus possible la recherche subventionnée. L'administration financière des subventions et les conditions régissant leur utilisation n'imposent au bénéficiaire qu'un minimum de restrictions, mais exigent de bonnes pratiques comptables et administratives.

Engagements

210. Le CRSNG reçoit du gouvernement des fonds pour ses programmes de subventions et bourses sous forme de crédits parlementaires annuels. Le CRSNG prend donc des engagements pour les années financières postérieures à l'année courante (p. ex. les deuxième et troisième versements de subventions de deux ou de trois ans) à la condition que les fonds soient alors disponibles. Le CRSNG ne peut donc accepter aucune responsabilité pour des engagements financiers qui dépassent les fonds disponibles dans le compte commun des subventions à l'université.

Période financière

207. Les subventions du CRSNG couvrent des dépenses encourues durant une période nommée période financière. La période financière des subventions thématiques commence le 1er novembre de l'année où la subvention est accordée et dure un, deux ou trois ans.

Frais indirects

214. Les bénéficiaires ne doivent pas utiliser les fonds octroyés par le CRSNG dans le cadre de ses programmes de subventions pour payer les frais indirects ou les frais généraux de recherche.

Salaires et traitements

217. Les bénéficiaires de subventions du CRSNG peuvent utiliser leurs subventions de recherche pour payer les salaires ou traitements de personnes qualifiées travaillant à temps plein ou à temps partiel dans leurs laboratoires. Cependant, les subventions ne peuvent être utilisées pour payer une partie du salaire du bénéficiaire, des membres de sa famille proche, des membres du personnel d'une université admissibles aux subventions du CRSNG ou encore de ceux qui reçoivent une autre forme directe d'aide du CRSNG. On ne peut utiliser sa subvention pour employer une secrétaire; on peut cependant l'utiliser pour payer les services de dactylographie pour les manuscrits et les rapports.

Summary of Salaries and Stipends from Grants

Assistants
—subject to university policies

Graduate students

—per annum:	$10,560
—per month:	$ 880

Postdoctoral Fellows

—maximum:	—per annum:	$21,720
	—per month:	$ 1,810
—minimum:	—per annum:	$18,420
	—per month:	$ 1,535

Visiting Scientists
—eligible for NSERC Grants: no salary or stipend
—not eligible: honorarium permitted

Résumé des salaires et traitements payés à même les subventions

Adjoints
—traitements sujets aux politiques de l'université

Étudiants (2e et 3e cycles)

—par an:	$10 560
—par mois:	$ 880

Stagiaires postdoctoraux

—maximum:	— par an:	$21 720
	— par mois:	$ 1 810
—minimum:	— par an:	$18 420
	— par mois:	$ 1 535

Chercheurs invités
—admissibles aux subventions du CRSNG: aucun salaire ni traitement
—non admissibles: honoraires permis

Purchase of Equipment and Other Materiel

232. When purchasing equipment and materiel, grantees must follow university procedures related to purchasing. Grantees must explore the possibility of purchasing equipment manufactured in Canada. Refer to paragraph 243 concerning the purchase of powered vehicles.

Achat d'appareillage et de fournitures

232. Les achats d'appareillage et de fournitures doivent respecter les politiques d'achat de l'université. Les bénéficiaires doivent étudier la possibilité d'acheter des appareils fabriqués au Canada. Consulter l'article 243 pour les règlements régissant l'achat de véhicules motorisés.

Ownership of Equipment and Other Materiel

233. All equipment and materiel (specialized books and publications, small assets such as cameras, small calculators, binoculars, tents, skis, etc.) purchased with NSERC grant funds belong to the university and not to the individual grantee.

When a researcher is moving to another Canadian university and wishes to move equipment or other materiel purchased with NSERC grant funds, Council encourages the university to accede to such a request provided the equipment is not necessary for the research activities of other researchers at that university. Assets so moved will belong to the new university.

Propriété de l'appareillage et d'autres biens

233. Tout appareillage et tout autre bien (livres et publications spécialisés, appareils-photo, calculatrices, jumelles, tentes, skis, etc.) achetés grâce à une subvention du CRSNG appartiennent à l'université, et non au bénéficiaire.

Lorsqu'un chercheur déménage dans une autre université au Canada et désire apporter avec lui les appareils ou autres biens achetés grâce à l'aide financière du CRSNG, le Conseil encourage l'université à accéder à une telle requête si les appareils ne sont pas nécessaires aux activités de recherche d'autres chercheurs de l'université. Les biens ainsi déménagés appartiendront à la nouvelle université.

Computing Costs

236. Grant funds may be used towards payment of charges for machine time, programming services and other related expenses essential to the conduct of the research for which the grant was awarded.

Frais d'ordinateur

236. Les subventions du CRSNG peuvent servir à payer le temps-machine, les frais de programmation et autres frais connexes lorsque de telles dépenses sont essentielles à la poursuite de la recherche pour laquelle la subvention a été accordée.

Patents

237. NSERC grantees are encouraged to seek patent protection for their inventions or developments, particularly in such a way that will benefit Canada. One method of accomplishing this is to consult with and use the services of Canadian Patents and Development Limited (CPDL). Many universities have an agreement with CPDL to achieve this end.

Brevets

237. Les bénéficiaires de subventions du CRSNG auraient avantage à protéger leurs inventions ou leurs découvertes, particulièrement de façon à en faire bénéficier le Canada. Ils peuvent, à cette fin, consulter la Société canadienne des brevets et d'exploitation Limitée (SCBE) et recourir à ses services. Plusieurs universités ont conclu à cet effet un accord avec cette société.

Publications

238. Grant funds may be used to purchase certain specialized publications not normally obtainable through the university library and that are essential to the research supported by Council. This may include special tables, catalogues of functions, published data, specialized journals and like material. Such publications belong to the university.

239. Grant funds may be used towards costs involved in the preparation of manuscripts, whether for articles in research journals or for books, and also towards the payment of page charges for publication in scientific journals. Grant funds must not, however, be used to pay for printing costs involved in the publication of a book.

240. Grantees are encouraged, whenever possible, to publish the results of their NSERC supported research in Canadian journals, including not only the Canadian Journals of Research published by the National Research Council, but other Canadian scientific and technical publications as well.

Publications

238. Les subventions peuvent être utilisées pour l'achat de publications spéciales, comme des tables de données, des catalogues de fonctions mathématiques, des revues spécialisées et autres renseignements de ce genre qui ne peuvent être obtenus dans les bibliothèques des universités et qui sont nécessaires à la bonne marche des travaux de recherche subventionnés par le Conseil. Ces publications appartiennent à l'université.

239. On peut se servir des subventions pour payer les frais encourus lors de la préparation des manuscrits, qu'il s'agisse d'articles dans des journaux scientifiques ou de livres, et pour payer les frais de publication dans des revues scientifiques. On ne peut se servir de ces fonds, cependant, pour payer les frais d'impression qu'entraîne la publication d'un livre.

240. On encourage les bénéficiaires de subventions à publier les résultats de leur recherche subventionnée par le CRSNG dans des journaux canadiens, si possible. Il peut s'agir non seulement des journaux canadiens de recherche publiés par le CNRC, mais aussi d'autres publications scientifiques et techniques canadiennes.

Acknowledgement of NSERC Support

241. In any publication arising out of research supported by Council grants, acknowledgement of NSERC assistance is expected.

Mention de l'aide du CRSNG

241. Le CRSNG s'attend à ce que les personnes bénéficiant de ses subventions mentionnent l'aide reçue lorsqu'elles publient les résultats de la recherche réalisée grâce à une subvention.

Travel Expenses

242. Grant funds may be used to pay travel and living expenses incurred in brief trips away from the grantee's university when these are essential to the research funded through the grant. The expenses may be incurred by grantees or by persons working with or for the grantees. Such trips include field trips (e.g. to collect specimens or samples or to use facilities located elsewhere), trips to consult with colleagues and attendance at conferences, meetings, symposia, institutes, etc., but do not include travel to and from the location(s) of sabbatical leave. However, brief local trips while on sabbatical leave are an allowable expense. Beneficiaries of operating grants who wish to spend three to six months on leave at another location in Canada must apply in writing to NSERC for permission to use operating grant funds for transportation expenses. See paragraph 206 for submission of travel claims.

Frais de déplacement

242. Les subventions du CRSNG peuvent servir à couvrir les frais de déplacement et de séjour encourus lors de brefs voyages à l'extérieur de l'université, lorsque ces voyages sont essentiels à la conduite des travaux de recherche subventionnés. Il peut s'agir des dépenses encourues par le bénéficiaire ou par les personnes travaillant pour lui. Ces déplacements comprennent les voyages vers les lieux d'expérience (cueillette d'échantillons ou utilisation d'installations de recherche) et les voyages pour consulter des collègues ou pour assister à des conférences, congrès, symposiums, etc. Ils ne comprennent pas les déplacements (aller retour) vers l'endroit où le chercheur passe son congé sabbatique, mais les frais de déplacement de courte durée encourus au cours du congé sabbatique sont admissibles. Les bénéficiaires de subventions pour dépenses courantes désireux de passer un congé de trois à six mois dans une autre institution au Canada doivent demander par écrit au CRSNG la permission d'utiliser leur subvention pour payer les frais de déplacement. Voir l'article 206 pour la réclamation des frais de déplacement.

Powered Vehicles

243. Recipients of NSERC grants may purchase a powered vehicle when essential for the pursuit of the research funded through the grant. However, prior university approval is required before purchasing any powered vehicle. By approving the purchase, the university accepts responsibility to provide insurance, any license required and to register the vehicle in the name of the university. Grantees may also use their grant funds to pay for the rental of such vehicles that are essential for the pursuit of the research funded through the grant.

Véhicules motorisés

243. Les bénéficiaires de subventions du CRSNG peuvent acheter un véhicule motorisé lorsqu'un tel véhicule est essentiel à la conduite des travaux de recherche subventionnés. Le bénéficiaire doit cependant obtenir l'approbation de l'université avant d'acheter tout véhicule motorisé. En approuvant l'achat, l'université accepte la responsabilité de fournir les assurances et les permis nécessaires et d'enregistrer le véhicule au nom de l'université. Les bénéficiaires peuvent également utiliser leurs subventions pour louer de tels véhicules, lorsqu'ils sont essentiels à la conduite des travaux de recherche subventionnés.

Organization of Conferences and Workshops

244. Grant funds must not be used to cover the costs of holding a conference or symposium. Canadian university staff members wishing to obtain funds to support the costs of travel and living expenses of guest speakers should apply for a conference grant (see paragraphs 152 to 160). Council does not have a program of support for attendance at conferences; however, operating grant funds may be used for this purpose (paragraph 242). Strategic grant funds may be used for the organization of workshops, provided the request was included in the application. In addition, NSERC is prepared to provide funding for the organization of university-industry workshops (paragraphs 124 to 126) or of other workshops (paragraph 161). Regulations governing these new programs will be stated in the conditions of the award.

Organisation de conférences et colloques

244. Il n'est pas permis de se servir des subventions pour payer les frais d'organisation de conférences. On peut se servir des subventions de recherche thématique pour organiser un colloque, à condition d'en avoir fait la demande. De plus, le CRSNG est prêt à subventionner des colloques dans le cadre de son programme universités-industrie (articles 124 à 126) ou dans d'autres circonstances (article 161). Les règlements s'appliquant à ces nouveaux programmes seront énoncés dans les conditions d'octroi. Si un membre du corps enseignant d'une université canadienne désire obtenir des fonds pour payer les frais de voyage et de séjour de conférenciers invités, il doit demander une subvention pour conférence (voir les articles 152 à 160). Le CRSNG n'a pas de programme de subvention pour venir en aide aux chercheurs qui participent à des conférences; les subventions de recherche peuvent cependant être utilisées à cette fin (voir l'article 242).

Equipment Grants

Equipment grants may only be used to purchase the equipment for which the grant was awarded. If recipients of equipment grants do not require the full amount awarded for this purpose, they must refund any remaining balance to NSERC. A researcher who is not able to purchase the equipment specified or who wishes to select alternative equipment must submit a written request to NSERC outlining the reasons for changing the selection. NSERC will assess the modified request and inform the grantee of its decision.

Subventions d'appareillage

Les subventions d'appareillage ne doivent servir qu'à l'achat de l'appareillage pour lequel la subvention a été accordée. On doit retourner au CRSNG tout montant non utilisé à cette fin. Un chercheur qui ne peut acheter l'appareillage décrit dans la demande ou encore qui désire choisir un autre appareil doit faire une demande écrite au CRSNG et donner les raisons du changement. Le CRSNG étudiera la demande et informera le bénéficiaire de sa décision.

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